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Scholarship for Nuclear Communications and Methods for Evaluation of Nuclear Project Acceptability

Fuel Cycle Research and Development

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FINAL REPORT

Project Title:	Scholarship for Nuclear Communication and Methods for Evaluation of Nuclear Project Acceptability (FC-5)
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Principal Investigator:	Dr. Michael Golay, (617) 253-5824, golay@mit.edu
Project Objective:	This project aims to go beyond effective communication in understanding how to design nuclear enterprise projects that will gain stakeholder acceptability. Much of what we are studying is generally applicable to controversial projects, and we expect our results to be of broad value beyond the nuclear arena. Acceptability is more than effective communication; it also requires varying degrees of engagement with a disparate number of stakeholder groups. In the nuclear enterprise, previous attempts have been well designed physically (i.e., technologically sound), but have floundered by being insensitive concerning acceptance. Though effective communication is a necessary, but insufficient, condition for such success, there is a lack of scholarship regarding how to gain stakeholder acceptance for new controversial projects, including nuclear ones. Our work is building a model for use in assessing the performance of a project in the area of acceptability. In the nuclear-social nexus, gaining acceptance requires a clear understanding of factors regarded as being important by the many stakeholders that are common to new nuclear project (many of whom hold an effective veto power). Projects tend to become socially controversial when public beliefs, expert opinion and decision-maker understanding are misaligned. As such, stakeholder acceptance is hypothesized as both an ongoing process and an initial project design parameter comprised of complex, social, cognitive and technical components. Controversial projects may be defined as aspects of modern technologies that some people question, or are cautious about. They could range from genetic modifications, biological hazards, effects of chemical agents, nuclear radiation or hydraulic fracturing operations. We intend that our work will result in a model likely to be valuable for refining project design and implementation to increase the knowledge needed for successful management of stakeholder relationships.

EXECUTIVE SUMMARY

The motivation for our work is to improve the ability of controversial projects, especially nuclear ones, to gain acceptance needed for their success. Large, energy-related projects—including nuclear projects specifically—are routinely plagued by persistent controversies that excite determined opponents and render the costs of such energy projects greater than if they were of no public interest. Such controversies are exacerbated by the fact that they very often represent real solutions to the most challenging issues of modern society. This reveals a need to improve stakeholder engagement knowledge and practices related to such socially controversial projects.

The long entrenched posture that if only the "public" were 'to know what the experts know, then they would also believe as the expert do' has proven repeatedly to be unfounded, yet repeated failures of "public education" have not resulted in improved stakeholder engagement. More specifically, the traditional nuclear style is to assume that a good product sells itself—especially if the technology was understood sufficiently—even when the stakeholders may be suspicious, powerless and uninformed. This has not worked, and is at least partially driven by the fact that the nuclear enterprise is led mainly by engineers who are not educated in social scientific areas. In response, eliciting insights from the social science literature regarding social attitudes and technologies can expand current efforts at stakeholder acceptance, including accounting for factors of the nuclear enterprise that make it special, to increase project success of socially controversial projects.

Objectives

Establishing a clear basis of scholarship concerning public beliefs, but also requirements for acceptance and means of satisfying these requirements better could make nuclear projects more efficient to implement and could bring their benefits to society more abundantly. Perhaps for the DOE's mandated 'consent-based siting' effort, a systematic approach to defining and measuring stakeholder acceptance could enhance both the categorization and analysis of relevant data and in designing tactical and strategic elements of a consent-based siting plan. This report chronicles efforts to establish this basis and demonstrates a method by which it can be used to fashion more broadly acceptable nuclear enterprise proposals. Employing the system dynamics modeling technique [1], based upon engineering control modeling, allows for stakeholder acceptance to be described as the result of simultaneous interaction and feedbacks of multiple important causal factors. The role of each factor can be entered into the models as a modulating variable affecting the rate of change of interacting conserved quantities. Figure 1, below, illustrates these dynamics.

Hypothesizing that stakeholder acceptance is both the result of an ongoing process and an initial project design factor, our work seeks a deeper understanding of complex, social, and technical components related to acceptance of controversial projects, with such specific research questions as:

- Is stakeholder acceptance a 'state of being,' rather than a reflection of effective communication, for socially controversial projects?
- Is stakeholder acceptance a dynamic, system-level characteristic of socially controversial projects?
- Is stakeholder acceptance initiated, maintained and (if needed) recovered differently for nuclear facilities than other types of socially controversial projects?

- Is there a fundamental difference in stakeholder dynamics related to nuclear projects not present in similar energy-related projects?

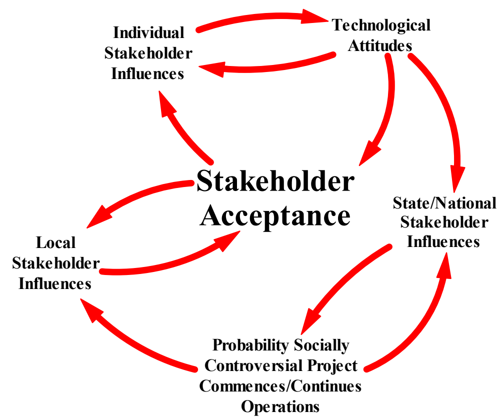

Figure 1. Theory-identified dynamic relationships between individual, local, state & national factors that influence stakeholder acceptance

Conclusions

The Golay-Williams Model [2]—built on an interdisciplinary foundation across relevant literatures, consistent with interview data and supported by case study analysis across energy projects—provides a mechanism to describe stakeholder dynamics and to prescribe engagement strategies to increase stakeholder acceptance in support of completing project goals. Results from research project supports the main research objectives:

- Stakeholder acceptance is more accurately modeled a 'state of being' rather than an effective communication strategy or education campaign;
- Stakeholder acceptance a dynamic, system-level characteristic of socially controversial projects; and,
- Fundamental differences between stakeholder engagement for nuclear projects versus other energy-related facilities—including differences in initiating, maintaining and recovering acceptance—exist.

Overall, the consistent trends across four cases studies and three types of energy-related projects indicates that the basic tenets of the Golay-Williams Model—namely, the stakeholder acceptance is a dynamic 'state of being' emerging (and balancing) from the interactions of components—are valid and applicable across these types of socially controversial projects. In addition, the differences between the two nuclear-related case studies and the two non-nuclear case studies show how the Golay-Williams Model describes how the former is 'different' from the latter. Further, our work provides general lessons learned from applying this new model to case studies [2] [3] [4] [5] [6] [7] [8], as well as an associated Stakeholder Engagement Manual to help project implementers utilize this model [9] [10]. In short, stakeholder management is represented as the result of dynamic balance between (the often complex and subtle) individual, local, state and national influences associated with a controversial project. Acceptance of socially controversial projects can be thought of as 'a condition where a project is allowed to proceed, given specific (tolerable) constraints.'

FINAL PROJECT QUAD CHART

U.S. DEPARTMENT OF ENERGY

Nuclear Energy

Scholarship for Nuclear Communications and Methods for Evaluation of Nuclear Project Acceptability

OVERVIEW

Purpose:
Development of a body of scholarship potentially useful to future nuclear project leaders seeking project acceptance from various (and often non-aligned) stakeholders.

Objectives:
- Develop a socio-technical theory of stakeholder acceptance for new/existing nuclear projects
- Develop a system dynamics model to make explicit the structure of this new socio-technical theory of stakeholder acceptance on new/existing nuclear projects
- Contribute to the academic literature regarding the various elements that influence stakeholder acceptance of nuclear projects

IMPACT

Logical Path:
1. Formulate literature-based model of nuclear project acceptance
2. Construct system dynamics model of nuclear project progression
3. Conduct interviews with former/current nuclear project stakeholders to understand factors determining their degrees of acceptance
4. Modify acceptance model & test model against previous experience
5. Design example nuclear fuel storage facility with 'acceptance' included as a facility performance goal
6. Test with sample stakeholders for acceptability & modify design and acceptance model as needed (repeat with second group of stakeholders)
7. Formulate conclusions and publicize results

Outcomes:
A new theory for and dynamic model of stakeholder acceptance for nuclear projects, and associated journal articles, conference papers/presentations and other publication avenues (as requested).

DETAILS

Principal Investigator: Dr. Michael Golay

Institution: Massachusetts Institute of Technology

Collaborators: N/A

Duration: Sept. 2012-Sept. 2016 **Total Funding Level**: $800,000

TPOC: Brent Dixon

Federal Manager: Ingrid Milton

Workscope: FC-6

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RESULTS

Results:
The system dynamics model generated from the literature review adequately explains many of the behaviors/phenomena identified in initial interview data. The major areas of development concern stakeholder relations and phenomena at the local, state and national levels, and concerning the influences of emotional reactions to potential radiological perils.

Accomplishments
Stage 1 deliverables (literature-based model of stakeholder acceptance) are developed.
Stage 2 deliverables (System dynamics model of stakeholder acceptance, reflecting literature-based model) has been developed.
Stage 3 deliverables (more interviews & expert discussions) are being scheduled.
Stage 4 deliverables (System dynamics model of stakeholder acceptance) have been validated (and refined) against interview data.
Stage 5 deliverables (extended scope acceptance model, including generalizability comparison studies) are complete.
Stage 5(a) deliverables (case studies of theory/model for WIPP, fracking & an alternative energy facility) are complete.
Stage 5(b) deliverables (case study of theory/model for comparing intra-state nuclear project & fracking acceptance) are complete.
Stage 6 deliverables (MIT CANES reports & journal article submissions) are complete.

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RESEARCH INTRODUCTION

Society cares about nuclear problems and is concerned with nuclear safety and its future. This is what makes working on solving them worthwhile. However, the nuclear enterprise has been plagued by persistent controversies that excite determined opponents and render the costs of nuclear proposals greater than if they were of no public interest. Understanding the basis of these controversies is a pressing, un-met need of the enterprise. The long entrenched posture that if only the "public" were 'to know what the experts know, then they would also believe as the experts do' has proven repeatedly to be unfounded. Yet repeated failures of related "public education" campaigns have not led to improvements in understanding and effectiveness of stakeholder engagement.

Establishing a clear basis of scholarship concerning public beliefs, but also requirements for acceptance and means of satisfying these requirements better could make nuclear propositions more efficient to implement and could bring their benefits to society more abundantly. This report chronicles efforts to establish this basis and demonstrates a method by which it can be used to fashion more broadly acceptable nuclear enterprise propositions. This work illustrates that the problem of understanding how to design nuclear enterprise propositions to gain stakeholder acceptability goes beyond effective communication. This is because many nuclear projects, despite having strong public relations and educational communications plans, have often floundered—being well designed physically, but insensitive concerning the dynamics of stakeholder acceptance. Effective communication is a necessary, but insufficient, condition for such success. More specifically, our experience in dealing with the nuclear-social nexus illustrates that gaining acceptance requires understanding and responding to factors regarded as being important by the many stakeholders that are common to nuclear proposals (many of whom hold effective vetoes). Among these factors— that were identified in this work that affect acceptance of nuclear projects—are:

- **Personal factors**: including level of local prosperity and opportunity, education, wealth, institutional affiliations and gender;
- **Technological factors**: including physical hazards, risks and benefits such as avoidance of environmental hazards and marginal project costs;
- **Project implementation factors**: including the project operator, and for institutions involved in the project implementation, records of past performance and institutional attributes such as competency and trustworthiness; and,
- **Social environmental factors**: including pressure group activity levels, history of nuclear accidents and alarms, and news media attitudes.

Our work provides an in-depth understanding of the full set of such factors and their interactions and translates them into project design variables that can be considered in performance acceptance requirements to increase successful implementation of nuclear projects. An innovation from the project is development of a project acceptance performance model intended for use by project leaders for design refinement in the hope of improving the probability of acceptance and success. Interviews of nuclear (and other large-scale energy-related) project stakeholders regarding the influences of the respective project attributes upon the project acceptability aided in validating and translating the factors identified above into overall acceptance performance models. The interviews reflected regional, demographics and experiential variability for a range of socially controversial energy-related (including nuclear) projects. Interview data reflected the range of factors listed above and aided in mapping the factors into explicit causal relationships that formed the basis of a quantitative model of stakeholder dynamics.

Employing the system dynamics modeling technique [1], based upon engineering control modeling, allowed for stakeholder acceptance to be described as the simultaneous interaction and feedbacks of multiple important causal factors. The role of each factor can be entered into the models as a modulating variable affecting the rate of change of conserved quantities that interact themselves. The model simulates the time-dependent trajectories of such performance factors reflecting the influences upon rates of change of the individual factors listed above. In effect, this model will identify the causal relationships and leverage points that a project can design and manage in the hope of successful acceptance. Once sufficiently developed, our model was evaluated against a in of case studies in regard to its ability to accurately and adequately describe the real-world complexity observed in managing stakeholder acceptance for socially controversial projects.

This work and model directly supports several DOE attempts at understanding better how the generate trust across stakeholders and public confidence in its endeavors. Work described herein should be of interest to the DOE's Consortium for Risk Evaluation with Stakeholder Participation (CRESP)[1] that seeks to

> 'advance cost-effective, risk-based cleanup of the nation's nuclear weapons production facility waste sites and cost-effective, risk-based management of potential nuclear sites and wastes…by seeking to improve the scientific and technical basis for environmental management decisions by the Department of Energy (DOE) and by fostering public participation in that search.'

Similarly, the 1993 Secretary of Energy Advisory Board (SEAB) Task Force on Radioactive Waste Management Report 'Earning Public Trust and Confidence: Requisite for Managing Radioactive Wastes' [11] describes how better interactions with external parties, internal operations and programmatic choices are needed to mitigate and overcome the complex realities of low public trust in the DOE, including observations that

- Distrust by the public of the DOE is not irrational, nor merely a symptom of 'not-in-my-backyard' (NIMBY) syndrome;
- Measures to strengthen public trust must go beyond appending minor efforts to reflect perceptions of what is required to restore trustworthiness in DOE-related projects; and,
- Trustworthiness and public confidence must be intentionally sought, vigorously maintained and (if necessary) humbly restored.

This task force, however, only offered conclusions for how the DOE might show that it is 'worthy of trust,' but did not provide any insight for explicit actions concerning *how to* increase public confidence or trust in DOE projects. Lastly, recent DOE efforts[2] to characterize better the

[1] For more, please see www.cresp.org

[2] Which consists of eliciting public feedback on five key questions: (1) How can the DOE ensure that the process for selecting a site is fair?; (2) What models and experience should the DOE use in designing this process?; (3) Who should

requirements for and implementation of consent-based siting [12] called for by the 2012 Blue Ribbon Commission Report [13] and the Obama Administration's 'Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste' [14] could be supported by our results. More specifically, unofficial correspondences with officials involved in this effort suggest that a systematic approach to defining and measuring stakeholder acceptance could enhance both the categorization and analysis of relevant data and in designing tactical and strategic elements for the DOE's mandated 'consent-based siting' effort.

OBJECTIVES

The primary objective of our work is to expand the body of knowledge related to stakeholder engagement, management and acceptance of nuclear projects. Starting with premise that stakeholder engagement efforts must expand beyond the use of effective communication strategies, our work sought a new approach to understanding the determinants of stakeholder acceptance. Specific research questions included the following:

- Is stakeholder acceptance a 'state of being,' rather than the result of effective communication, for socially controversial projects?
- Is stakeholder acceptance a dynamic, system-level characteristic of socially controversial projects?
- Is stakeholder acceptance initiated, maintained and (if needed) recovered differently for nuclear facilities than other types of socially controversial projects?
- Is there a fundamental difference in stakeholder dynamics related to nuclear projects not present in similar energy-related projects?

Ultimately, this work has relevance beyond the nuclear enterprise, as any large project today attracts opposition from some stakeholders—this is a fact of American life. Learning how to render large projects more acceptable from their initiation can be expected to be nationally valuable, independent of whether the success of the nuclear enterprise is a value. Such projects are essential to modern life, and would benefit from learning how to make them more acceptable and efficient.
Toward this end, the Golay-Williams Model for Stakeholder Acceptance for Socially Controversial Projects may be valuable.

EMPIRICAL INVESTIGATION

KEY PHENOMENA FROM LITERATURE REVIEW

The complexity and intricacy of stakeholder dynamics led us to review and draw key insights from a broad range of academic literatures, including studies of risk, risk perception, social attitude formation, technological adoption, and management.[3]

Wang, et. al. [15] offer a useful literature survey which traces the evolution of the definition of the

be involved in the process for selecting a site, and what is their role?; (4) What information and resources do you think would facilitate your participation?; and, (5) What else should be considered?

[3] For a comprehensive working list of references from our work, please see Appendix B.

term 'stakeholder' and categorizes various stakeholder analytical approaches for the engineering community. We recognize a range of potential stakeholder sets—from groups or individuals whose participation is mandatory for organizational survival to a broader potential set of any groups or individuals who is affected by organizational success. Despite the differing formulations, we see the set of stakeholders can include employees, suppliers, contractors, government, creditors, insurers, shareholders, consumers, trade unions, local communities, competitors, media and non-governmental organizations. In addition, several categorizations of stakeholders can include primary (e.g., essential relationships) versus secondary (e.g., interactive relationships) and the definitive, expectant and latent stakeholders attributed to the [16] power, legitimacy and urgency stakeholder framework. Because of the growing realization that stakeholders can influence organizational (or engineering project) success, the authors conclude that it 'is more urgent to investigate how to encourage stakeholders participating actively, and how to decide upon an effective mechanism to achieve the goal of organizations or policies by affecting behaviors of stakeholders' [15, p. 41].

Traditional approaches to garnering stakeholder acceptance in controversial projects, however, tend to assume that a good product sells itself—especially if understood—even when the stakeholders may be suspicious, powerless and uninformed [17]. The ineffectiveness of this approach is partially the result of controversial technologies being perceived as sufficiently different from other engineering projects to such a degree that much of the literature is of limited direct value. This is also partially due to the fact that often the engineers involved in controversial projects are not well-versed in related social science areas. Further, experience indicates that gaining acceptance requires clear communication of factors important to various stakeholders common to the controversial project (many of whom hold effective vetoes). Though necessary, this communication alone is not sufficient to gain stakeholder acceptance, as clarity concerning the influences of technological perceptions, organizational bias, institutional loyalty, social trust, personal empowerment, irreversibility, time duration, benefits and opportunities on stakeholder acceptance is needed.

In response, we identified a set of core tenets to guide the development of a new model for stakeholder acceptance. The first tenet is the existence of a 'system' of social, organizational, technical and political influences that can either reinforce or negate individually developed beliefs related to stakeholder acceptance of controversial projects [1] [18]. In other words, the dynamics related to stakeholder acceptance emerge from a system that, if understood, could help influence individual attitudes regarding socially controversial technologies (e.g., nuclear facilities) in desired directions. A second tenet is that of a need to understand and characterize better the differing perspectives of the acceptance of controversial projects. In general when it comes to debates, experts (or highly educated stakeholder groups) see 'solvable technical problems' but the public and/or policy-makers may instead see an 'intractable policy conflict.' This impasse greatly influences the arguments used to support and oppose controversial endeavors, often attempting to convert a stakeholder with a differing perspective using the wrong kind of argument. Here concerning nuclear waste disposal, we coin the term the 'Santa Fe Effect,' which is explained by the fact that

> 'There are no benefits in Santa Fe [New Mexico] from economic activity in Carlsbad, New Mexico [site for the Waste Isolation Pilot Plant (WIPP)], and no pain in distrusting people you have never met. Opposition to burying nuclear waste near Carlsbad has been intense in Santa Fe, where nothing from direct experience challenges the "better safe than sorry [e.g., only seeing the danger and not seeing

potential opportunity]" argument' [19, p. 132].

The last tenets are centered around accounting for the different roles of perceived vs. objective truth in stakeholder acceptance for socially controversial projects. Given that it is very difficult to define (and communicate) objective truth or set a standard for many of the variables germane to acceptance-related decision making, it is important to account for the differences between perception and objectivity. The idea of the gap between perception and objective truth is an important one – where objective truth signifies the existence of a cognitive connection to a complex entity (e.g., new nuclear project). In the absence of such a cognitive connection, a range of heuristics are used to reduce the complexity in question to a manageable level, such as availability [20], affect [21] [22] or anchoring & adjustment [23]. Using differences in cognitive connections helps to capture the important stakeholder dynamics ranging the gap between objective and perceived truth. These core research tenets can help to bound our exploration across multiple academic disciplines in identifying causes, concepts and paradigms to aid more robust understanding of stakeholder acceptance of socially controversial projects. These key tenets—and how the manifest themselves as key phenomena across stakeholder levels—are summarized in Table 1, below. (For more, please Appendix B).

Table 1. Key Phenomena Influencing Stakeholder Acceptance in the Golay-Williams Model for Stakeholder Acceptance

Theory Level	Key Phenomena
Across All Levels	'System' of socio-technical influences that reinforce/negate individual beliefs
	Differences in acceptance between stakeholder groups
	Perceived vs. objective truth/cognition
Local Model Level	Rigorous model of radiation attitudes
	Support of concept vs. a specific facility
	Actual (operational) vs. expected benefits
	Role of credibility of project implementer
	Novel/cognitive conception of risk
	Trust asymmetry principle
	'Probability neglect' in risk assessment
	Role of core stakeholder values
	Social trust in project implementer
	The 'snowball' nature of opinion change
	Influence of popular culture/perceptions
State/ National Model Level	Congressional dynamics between states hosting, states with facilities served by & states not served by the socially controversial project

SOCIO-TECHNICAL SYSTEM PARADIGM

Given the insights garnered from the literature review, our work is based on a socio-technical paradigm [18]. Here, the (often) unexpected behaviors observed in real-world projects are conceptualized as emerging from the interactions of technical component and social influences.

More specifically, this paradigm describes observed behaviors as system-level properties that cannot be explained solely by functionally understanding each of the elements identified as relevant. In addition, a socio-technical system perspective expands the set of elements considered relevant and emphasizes the interdependence between them in explaining non-linear behaviors observed at the system level. This paradigm also aids in identifying—and responding to—the intricacies and between variables and complexities in variable relationships that can significantly alter desired system behaviors.

Here, stakeholder acceptance is represented as the balance between (the often complex and subtle) individual, local and state/national influences associated with a controversial project. For example, Figure 1 is a simplified representation of how this emerging theory and model incorporate local, state and national level factors, relationships and dynamics. **Acceptance** of socially controversial projects can be thought of as '**a condition where a project is allowed to proceed, given specific (tolerable) constraints**.' In addition, this definition suggests that stakeholder acceptance is a system-level property that exists at all stages of the socially controversial project's life-cycle. In other words, stakeholder acceptance is not a 'one-time' achievement, but must be initiated, maintained and (if lost) recovered by the socially controversial project.

Considering the time-dependent nature of stakeholder acceptance implicit in this definition, system dynamics modeling is a useful approach for subsequent describing and analyzing the complex behavior of stakeholder acceptance. System dynamics is a technique based upon engineering control modeling that emphasizes the simultaneous interaction of multiple important factors in system feedbacks [1]. The role of each factor can be modeled as a modulating variable affecting the rate of change (quickly or slowly increasing or decreasing) of conserved quantities (social trust, perceived benefit, political benefit, etc.) – that themselves interact non-linearly. Causal loop diagrams (CLD) are graphical representations that illustrate the directionality of relationships between model variables. In a CLD, an arrow illustrates the hypothesized direction of causality, a '+' represents a positive (or increasing) relationship and a '-' represents a negative (or decreasing) relationship. CLDs provide a qualitative model of the system of interest, but also provide a mechanism for analyzing the dynamic relationships between variables. The influence of specific variables, relationships or feedback loops (e.g., based on observed actions related to the system) on overall behaviors can be evaluated with the explicit causality exhibited in CLDs.

DATA COLLECTION

In order to evaluate this socio-technical system approach adequately to stakeholder acceptance, we identified two data collection techniques capable of providing appropriate and useful insight into the complexity and multi-dimensionality described above. First, qualitative interviews (described below) allow for researchers to identify the 'why' behind the 'what' of an answer (or series of answers), illuminating the often implicit beliefs, assumptions and meanings behind explicit statements of intent. Second, case studies provide a mechanism to explore higher explanatory fidelity when the problem at hand has many more variables than possible to include in an analytic model. These two data sources provide rich, data with which to challenge, refine and validate our new approach to stakeholder acceptance for socially controversial projects.

The collection of a large set of scheduled, qualitative interviews[4] [24] [25] began in early 2013. A set of reference questions was used to guide discussion, and were dynamically refined based on interviewee comments in order to obtain more accurate and comprehensive responses for developing the theory and model. All interviews were conducted in a conversational manner, averaged 60 minutes in duration and were conducted in person (22) or by telephone (20). The analysis of these interviews relies less on counting and correlating, and more on trend analysis, interpretation, summary and integration. These interviews, summarized in Table 2, can be described in two broad categories: model development and model validation. The interviews in the first category focused on identifying a converging set of variables and relationships in the model that adequately captured phenomena identified in the literature review, practical experience and interview data. The second category of interviews focused on validating that the variables and feedback relationships accurately reflect key phenomena identified in the literature review and interview data. Some of the interviews in the second category also supported related case studies. The interviews include a wide range of experts across a wide range of experience with stakeholder acceptance in socially controversial projects, as a well as spans a range of demographic, geographic and stakeholder group characteristics.

Table 2. Summary of qualitative interviews for developing & validating the Golay-Williams Model for Stakeholder Acceptance

Interviewee Number	Interviewee Descriptions
1	Potential nuclear project stakeholder that is a well-educated Massachusetts resident between 50-80 years old A
2	Potential nuclear project stakeholder that is a well-educated Massachusetts resident between 50-80 years old B
3	Potential nuclear project stakeholder that is a well-educated Massachusetts resident between 50-80 years old C
4	Potential nuclear project stakeholder that is a well-educated Massachusetts resident between 50-80 years old D
5	Potential nuclear project stakeholder that is a well-educated Massachusetts resident between 50-80 years old E
6	Potential nuclear project stakeholder that is a well-educated Massachusetts resident between 50-80 years old F
7	Manager of a large project having many stakeholders
8	Stakeholder manager at local university
9	High school AP history teacher
10	High school AP physics teacher
11	Experienced IT project manager
12	U.S. Air Force project manager
13	High school students (2) enrolled in AP classes
14	High school students (2) enrolled in AP classes
15	Stakeholder manager at local university
16	Nuclear researcher
17	NPP#1 Director of government relations
18	NPP#1 Lead Manager of government relations
19	NPP#1 Vice President
20	Legislative aide for the county supervisor near a nuclear power plant site
21	District supervisor for the county a nuclear power plant site
22	Union representative for skilled contractors a nuclear power plant site
23	Manager at county office of emergency services a nuclear power plant site
24	Director of governmental affairs at the city chamber of commerce a nuclear power plant site
25	Vice President and senior relationship manager at a bank a nuclear power plant site
26	Workforce services director for the county a nuclear power plant site
27	Emergency personnel stakeholder a nuclear power plant site
28	State level energy-related nongovernmental organizational leader

[4] All interviews were governed by the MIT protocols for use of human subjects along with the assurance of confidentiality for all interviewees.

29	Independent energy consultant
30	Environmental NGO representative
31	Self-Reliance Corporation Executive Director
32	Energy project leader A
33	Energy project leader B
34	Energy project leader C
35	National laboratory energy expert
36	Nuclear utility leader
37	Nuclear utility public affairs leader
38	High school teacher
39	Federal Aviation Administration subcontractor
40	Former Executive of Environmental Evaluation Group A
41	Former Executive of Environmental Evaluation Group B
42	Senior official of a university energy & environment research group

Each set of interviews—in addition to supporting overall model development validation—yielded specific key insights that enriched our research. Interviews #1 to #6 provided data necessary to capture the dynamics at the individual level regarding stakeholder acceptance. Exploring the reasons why nuclear projects elicit stronger, more visceral reactions than similar non-nuclear projects, the concept of radiation attitudes[5]—'the reaction provoked in an individual by radiation, which may range from active acceptance of nuclear technology to a high level of anxiety' emerged [26]. Interviews #7 to #16 supported the three-tiered model structure to initiate, maintain and (if needed) recover stakeholder acceptance and helped restructure several key feedback loops in the model to better describe the complex dynamics of stakeholder acceptance. They also identified the theme of building trust-based stakeholder relationships—and resulted in the development of a related stakeholder engagement manual [9] [10].

Interviews #17 to #27 validated the importance of recovering stakeholder acceptance, the representation of radiation attitudes, the key role of social trust and how need to align project implementer action with core stakeholder values [7]. These interviews also supported a case study of a U.S. Nuclear Power Plant [4]. Interviews #28 to #35 investigated a controversial New England offshore wind energy project [8] and, because of its unique characteristics, both validated many of the variables, relationships and loops and tested the analytical limits of this stakeholder acceptance model [3]. Interviews #36 to #49 were 'interviews of opportunity' taken at a later stage of model development to validate further structure, dynamics and preliminary conclusions and reinforced key model dynamics like the social trust loop and perceived benefits dynamics. Interviews #40 and #41 investigated the Waste Isolation Pilot Plant (WIPP) case study, in particular to the role of an independent, technical oversight group in the stakeholder dynamics throughout WIPP's development and early operations [5] [4]. Lastly, interview #42 supported a case study in hydraulic fracturing (also known as 'fracking') focusing on the Marcellus Shale for more contextualized information on local attitudes toward fracking [6] [3].

The completion of a series of case studies began in early 2014 and was based on identifying key nuclear projects of interest, as well as identifying projects from across different large-scale, energy projects. In general, data for each study were elicited from local media reporting (e.g., the immediate nearest printed newspaper); neighboring and/or state printed newspapers; national new media coverage; historical documents and relevant conference or journal papers. These data sources were

[5] It should be noted that comments from these interviews (and others) supported the logical extension of this key concept to 'technological attitudes' for many large-scale, engineering socially controversial projects.

combined with data gained from several unique sources related to each case study. More specifically, the wind energy project case study gathered data from such additional sources as regulatory reports (from different regulating bodies), legal reviews, public hearing transcripts and stakeholder meeting transcripts. Additionally, the WIPP case study was bolstered by data gathered from recordings of bi-weekly town hall meetings in Carlsbad, NM; regular news updates at its official website and documents published by its now disbanded independent, technical oversight entity. Lastly, for the hydraulic fracturing (fracking) case study, various other academic and non-governmental studies attempting to explain the acceptance of unconventional gas production were included because of the rich insights present in the associated local and regional survey; interview and ethnographic observation data. These cases, and a summary of why they were selected, are shown in Table 3 below.

Table 3. Summary of case studies conducted to evaluate the Golay-Williams Model of Stakeholder Acceptance for Socially Controversial Projects.

Case	Energy-Type	Reason(s) Selected
NPP #1	Nuclear (Power)	History of successful stakeholder engagement
		Recently underwent 3 plant projects that challenged stakeholder acceptance
		Illustrate dynamics of a civilian nuclear facility
Offshore Wind Energy	Wind Power	Test the analytical limits of the model
		Evaluate energy-technologies not often considered 'socially controversial'
		Test generalizability of new concept & model
WIPP	Nuclear (Waste)	Cited by 2012 BRC as 'model' of consent-based siting
		February 2014 radiological releases challenged stakeholder acceptance
		Illustrate dynamics of a defense nuclear facility
Fracking	Natural Gas	Evaluate similar dynamics between nuclear & fracking projects
		Many previous studies on stakeholders were available for comparison
		Test generalizability of new concept & model

DATA ANALYSIS

All phases of data analysis were guided by the core principles of grounded theory to not only uncover relevant conditions for stakeholder acceptance, but also to determine how members of various stakeholder groups actively respond to those conditions and to the consequences of those actions. Because grounded theory does not describe phenomena of interest as being static but as continually changing in response to prevailing conditions, it provides a useful vehicle for understanding the various dynamics observed influencing stakeholder acceptance. Other tenets of grounded theory that guided our work include: data collection and analysis are intertwined processes; patterns and variations in the data must be accounted for; and, these hypotheses about relationships must be developed and verified as is feasible during the research process [27]. As such, a grounded theoretical evaluation for the Golay-Williams Model includes a set of well-developed, systematic conceptual linkages that account for variation in the data and broader influencing conditions, and that provide significant conclusions about the phenomena of interest (e.g., stakeholder acceptance for socially controversial projects).

Analysis of qualitative interview data is based upon identifying, coding and sorting trends and relationships between variables of interest. Once initial coding and sorting is completed, identified themes and relationships are locally integrated into 'mini-theories' that find meaning beyond the variables themselves. These mini-theories, in turn, often converge during the process of inclusive integration wherein vital, high-level trends emerge from the raw interview data. This is an interative process that finally settles out when clear connections from the data and mini-theories result in causal relationships answering the research question [24]. Similarly, analysis of case study evidence is predicated on developing clear case descriptions, working data from a 'grounded' perspective, relying on theoretical propositions and eliminating plausible rival explanations. For this study, pattern matching (the level of consistency between empirically based and expected, theoretical patterns), explanation building (explicitly stipulate a presumed set of causal links about 'how' or 'why' the event occurred) and logical models (examining a theory of change by comparing observed and expected outcomes) [28] were each used to analyze the data for each case and draw conclusions.

Further, cross case study comparison and a multi-method analysis of both types of collected data provided a meta-analysis on the Golay-Wililams Model. The degree of consistency across these meta-studies indicates how well the data fit the theoretically developed causal mechanisms of this new stakeholder acceptance model, then more confidence can be placed on the same causal mechanisms influencing stakeholder acceptance for other large-scale energy projects.

RESULTS

GOLAY-WILLIAMS MODEL OF STAKEHOLDER ACCEPTANCE FOR SOCIALLY CONTROVERSIAL PROJECTS

The Golay-Williams Model of Stakeholder Acceptance for Socially Controversial Projects, and its theoretical foundations, seeks to explain the acceptance of new controversial projects, especially among various stakeholders (project implementers, local decision-makers, surrounding communities, national regulators, etc.). The Golay-Williams Model hypothesizes that stakeholder acceptance is both an ongoing process and an initial project design parameter goal, consisting of complex, social, cognitive and technical components described in the dynamics of socially controversial projects. Further, stakeholder acceptance is represented as the balance between (the often complex and subtle) individual, local and state/national influences associated with a controversial project. Acceptance of socially controversial projects can be defined as 'a condition where a project is allowed to proceed, given specific (tolerable) constraints'—suggesting that stakeholder acceptance is a system-level property that exists at all stages of the socially controversial project's life-cycle. In other words, stakeholder acceptance is not a 'one-time' achievement, but must be initiated, maintained and (if lost) recovered by the socially controversial project. The Golay-Williams Model consists of three, interconnected CLDs:

- Individual stakeholder CLD
- Local stakeholder CLD
- State/National stakeholder CLD

The individual stakeholder CLD captures and describes the individual influences affecting stakeholder acceptance for a socially controversial project. These individual influences are captured in a variable 'Technological Attitudes' – which represents the comprehensive reflection of personal attitudes to radiation-producing processes or facilities. In this CLD 'technological attitudes' is both the influenced variable (being increased with a decrease in 'perceived personal risk,' for example) and the influencing variable (with its increase resulting in increased 'social trust in the project implementer,' for example). More specifically, if an individual cognitively frames a socially controversial project positively, their inherent, tacitly believed narrative about related technologies that influences decision-making will be similarly positive. As this personal narrative remains positive, general individual attitudes toward a socially controversial project will remain positive. Positive attitudes toward a socially controversial project result in a reinforcing of the positive cognitive framing. This describes the reinforcing nature of the R(R.A.)2 feedback loop in Appendix D.

More specifically, Figure 2, below, offers a representation—simplified from a more comprehensive model to illustrate primary causal pathways—of 'technological attitudes' as both the influenced variable (being increased with a decrease in 'perceived personal risk,' for example) and the influencing variable (with its increase resulting in increased 'personal & social trust in the project implementer,' for example). More specifically, if an individual cognitively frames the socially controversial facility positively, their inherent, tacitly believed narrative about related technologies that influences decision-making will be similarly positive. As this personal narrative remains positive, general individual attitudes toward the socially controversial project will remain positive. Positive attitudes toward the socially controversial project result in a reinforcing of the positive cognitive framing. This describes the reinforcing nature of the feedback loop in the upper right corner of Figure 2.

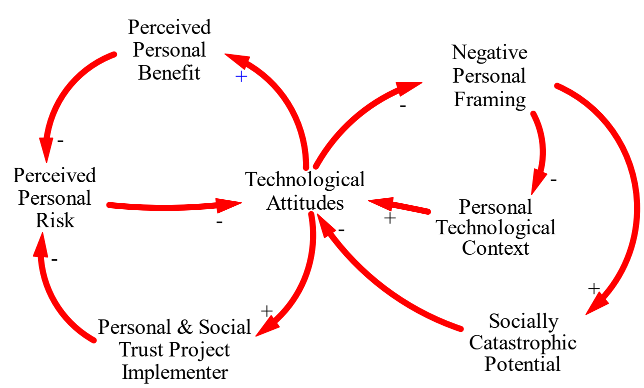

Figure 2. Simplified causal loop diagram illustrating dynamic relationships influencing individual technological attitudes.

Similarly, Figure 3 illustrates the local influences affecting stakeholder acceptance for a socially controversial project. These local influences are captured in the variable 'Stakeholder Acceptance' – which represents the extent to which stakeholder groups support a socially controversial project. In this CLD 'stakeholder acceptance' is both the influenced variable (being increased with an increase in 'perceived benefit from project,' for example) and the influencing variable (with its increase resulting in an increased 'probability stakeholder safety & security concerns are met,' for example). More specifically, if a socially controversial project can mirror the social values through involvement in local philanthropy (for example), social trust is built. This trust reinforces the likelihood of the benefit being received. As this likelihood increases, the magnitude of perceived benefits associated with a socially controversial project (e.g., property values) also increase. As long as these perceived benefits persist, stakeholder acceptance will remain positive. The higher the stakeholder acceptance, the more efforts by a socially controversial project's implementer to encapsulate local values are successful. This describes the reinforcing nature of the R(L)2 feedback loop in Appendix D.

More specifically, Figure 3 offers a representation—simplified from a more comprehensive model to illustrate primary causal pathways—of 'stakeholder acceptance' as both the influenced variable (being increased with an increase in 'perceived benefit from project,' for example) and the influencing variable (with its increase resulting in an increased 'social opportunity/danger tradeoff,' for example). More specifically, if the project implementer of a controversial project is able to mirror the social values of the local community through involvement in local philanthropy (for example), social trust is built. This trust reinforces the magnitude of perceived benefits associated with the controversial project (e.g., increased property values). As long as these perceived benefits persist, stakeholder acceptance will remain positive. The higher the stakeholder acceptance, the more efforts by the project implementer to encapsulate local values are successful. This describes the reinforcing nature of the feedback loop in the upper right corner of Figure 3.

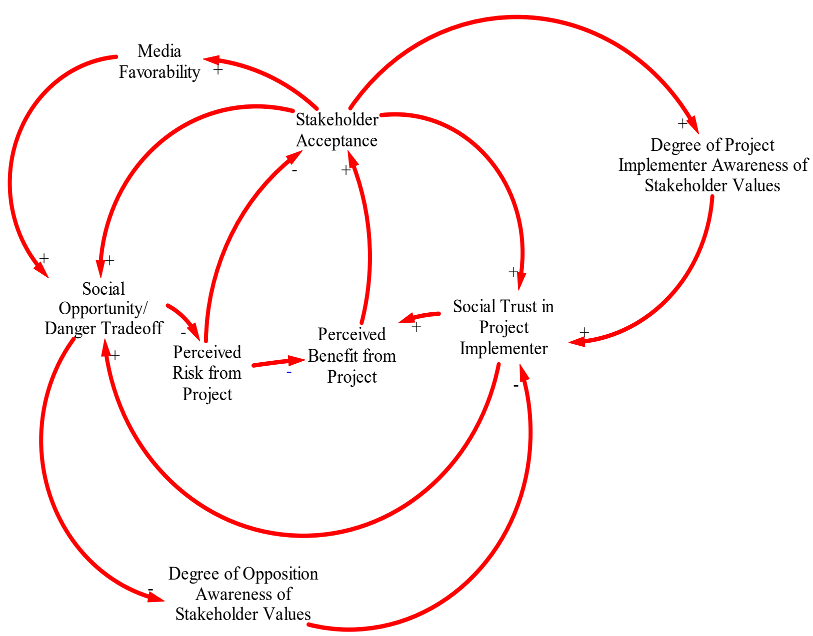

Figure 3. Simplified causal loop diagram illustrating dynamic relationships influencing local stakeholder group acceptance.

Lastly, Figure 4 illustrates the state/national influences affecting stakeholder acceptance for WIPP. These influences are captured in the variable 'Probability Specific Nuclear Project Commences/ Continues Operations' – which represents the likelihood that a socially controversial project is allowed to continue operations. In this CLD 'probability specific nuclear project commences/ continues operations' is both the influenced variable (being increased with a decrease in 'specific nuclear project cost overrun,' for example) and the influencing variable (with its increase resulting in an increased 'state/local economic benefits of specific nuclear project received,' for example). More specifically, as a socially controversial project maintains operations, it becomes more valuable to state and national stakeholders. Being highly regarded can help stem controversy associated with publically or politically supporting a socially controversial project. As long as any associated controversy is decreasing, the likelihood of financial support increases, which in turns reduces opportunities for cost overruns or schedule creep. The fewer budget or schedule problems that emerge, the better able a socially controversial project is to maintain orderly operations. This describes the reinforcing nature of the R(S/N)9 feedback loop in Appendix D.

More specifically, Figure 4 offers a representation—simplified from a more comprehensive model to illustrate primary causal pathways—of the 'probability specific socially controversial project commences/continues operations' as both the influenced variable (being increased with a decrease in 'specific socially controversial project cost overrun,' for example) and the influencing variable (with its increase resulting in an increased 'actual value of the socially controversial project,' for example). More specifically, if the socially controversial project is able to maintain operations, the project becomes more valuable to state and national politicians and stakeholders. A highly regarded project can help stem attempts to generate controversy associated with publically or politically supporting the project. As long as any associated controversial is minimal or decreasing, the likelihood of national financial support increases, which in turns reduces opportunities for cost overruns or schedule creep. The fewer budget or schedule issues that emerge, the better able the socially controversial project is to maintain operations. This describes the reinforcing nature of the feedback loop in the central right corner of Figure 4.

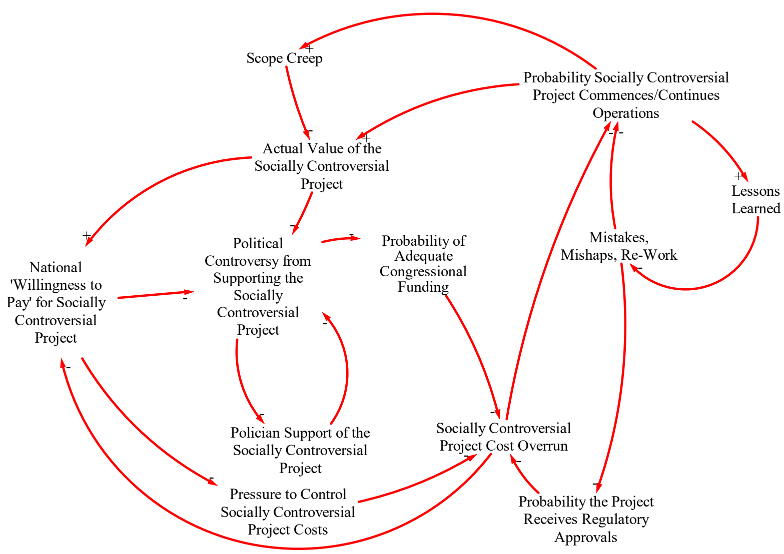

Figure 1. Simplified causal loop diagram illustrating dynamic relationships influencing state & national stakeholder decisions to allow a project to continue operations.

Table 4, below, provides a full list of CLD variables and feedback loops. Comprehensive definitions, relative quantifications of model variables (Appendix E) and feedback loop explanations (Appendix F) have been developed to describe and evaluate the dynamics of multi-faceted stakeholder acceptance. Using these CLDs—more specifically the interaction between the variables and feedback loops—the Golay-Williams Model describes the complex, multifaceted dynamics underpinning stakeholder acceptance for socially controversial projects.

Table 4. List of variables in the Golay-Williams Model of Stakeholder Acceptance for Socially Controversial Projects

	Variable Name	Feedback Loop Name
Technological Attitude CLD Variable	• Exposure to Apocalyptic Film & Literature (i) • Exposure to Expert Communication (i) • Familiarity with Nuclear Science & Technology • Fear of "Nuclear Winter" • Fear of Long Term Effects of Radiation • Level of Education • Negative Personal Framing (c) • Nuclear Weapons Association (i) • Perceived Detectability of Radiation • Perceived Personal Benefit • Perceived Personal Control • Perceived Personal Risk • Perceived Scientific Expert Agreement (i) • Personal Knowledge Framing (c) • Personal Nuclear Context • Personal Sense of Uncertainty • Personal Trust in Project Implementer to Respond Competently to Problems • Popular Culture Perception (i) (c) • Probability Negative Message is Trusted • Probability of Selecting Media Source with Negative Framing • Probability of Threat Being Viewed as "Man-made" • Proximity to Nuclear Event (i) • Radiation Attitudes (c) • Socially Catastrophic Potential • Socio-political Awareness & Involvement (i)	• R(R.A.)1: Radiation Attitude/Social Trust Loop (c) • R(R.A.)2: Personal Framing Loop • R(R.A.)3: Radiation Attitudes & Social Catastrophe Loop • R(R.A.)4: Personal Benefit vs. Risk Loop • R(R.A.)5: Personal Control vs. Uncertainty Loop • R(R.A.)6: Media vs. Personal Framing Loop
(c) indicates a 'connecting variable/feedback loop' (a variable/feedback loop present in more than one CLD) • **(i)** indicates an 'initializing variable (a variable with no causal input)		

Table 4 (continued). List of variables in the Golay-Williams Model of Stakeholder Acceptance for Socially Controversial Projects

Local Stakeholder CLD Variable	• Cognitive Inclusion of Perceived Threat Frequency • Credibility of Negative Framing • Degree of Implementer Awareness of Stakeholder Values • Degree of Opposition Awareness of Stakeholder Values • Importance of Publicized Mistake to Stakeholder • Local Socioeconomic Condition (i) (c) • Media Favorability (c) • Negative Social Framing (c) • Perceived Benefit from Project • Perceived Frequency of Risk Event • Perceived Positive Environmental Effects (i) • Perceived Pride in New Specific Nuclear Project (i) • Perceived Probability Nuclear Waste Issue is Resolved*** • Perceived Probability of Competent Project Implementation (c) • Perceived Risk from Project • Perceived Stakeholder Empowerment (i) (c) • Perceived Transparency of Project Implementer • Probability Benefit is Realized • Probability First Reporting of Publicized Mistake is from the Project Implementer (i) • Probability Project Stakeholder Safety and Security Concerns are Met (c) • Social Danger (c) • Social Equity/ Injustice Balance (i) • Social Opportunity • Social Opportunity/Danger Tradeoff • Social Trust in Project Implementer (c) • Stakeholder Acceptance (c)	• R(L)1: Social Danger & Perceived Risk Loop • R(L)2: Perceived Benefit vs. Implementation Loop • R(L)3: Tradeoff vs. Risk Loop • R(L)4: Social Framing vs. Tradeoff Loop • R(L)5: Risk Frequency Inclusion Loop • R(L)6: Personal Knowledge vs. Social Framing Loop (c) • R(L)7: Social Trust vs. Publicized Mistake Loop • R(L)8: Media Opinion vs. Social Opinion Loop • R(L)9: Nuclear Waste & Opposition Loop • R(L)10: Social Trust vs. Opposition Loop • R(L)11: Social Trust vs. Benefit Loop • R(L)12(a&b): Stakeholder Acceptance vs. Radiation Attitudes Loop(s) (c)
(c) indicates a 'connecting variable/feedback loop' (a variable/feedback loop present in more than one CLD) **(i)** indicates an 'initializing variable (a variable with no causal input)		

Table 4 (continued). List of variables in the Golay-Williams Model of Stakeholder Acceptance for Socially Controversial Projects

State/ National Stakeholder CLD Variable	• Actual Value of the Specific Nuclear Project • Additional Regulatory Approval Expectations • Anti-Nuclear NGO Legal & Social Activities (c) (i) • Essential Stakeholder 'Peer Pressure' for Continued Specific Nuclear Project Operations/ Construction • Host State Cong Rep National Political Benefit of Supporting the Specific Nuclear Project • Host State Constituent Support for the Specific Nuclear Project • Host State Stakeholder Consensus in Support for the Specific Nuclear Project • Improved Project Implementer Capability with One-of-a-Kind Nuclear Project (c) • Incentives to Nuclear Facilities for Using Specific Nuclear Project (i) • Lessons Learned • Mistakes, Mishaps, Re-Work • National Expected Specific Nuclear Project Cost • National Need Specific Nuclear Project • National SNM Perception Benefit*** • National 'Willingness to Pay' for Specific Nuclear Project • Negative Specific Nuclear Project Event (i) (c) • One-of-a-Kind Nuclear Project Construction Uncertainty • One-of-a-Kind Nuclear Project Design Uncertainty • Operations Approaching Limits of Capability • Oversight Entity Reported Specific Nuclear Project Cost • Perceived Project Implementer Regulatory Approvals Application Quality • Political Controversy from Supporting the Specific Nuclear Project (c) • Politician Support of the Specific Nuclear Project by Host State Cong Reps • Pressure to Control Specific Nuclear Project Costs • Pro-Nuclear NGO Legal & Social Activities (c) (i) • Probability Specific Nuclear Project Commences/Continues Operations (c) • Probability of Adequate Congressional Funding • Probability of Criticism of National Regulating Entity • Probability of Expanding Specific Nuclear Project Operational Scope • Probability of Host State Cong Rep Re-Election from Supporting the Specific Nuclear Project • Probability of Need to (Re)Design Specific Nuclear Project Construction/Expansion • Probability of Success of Specific Nuclear Project Alternative(s) • Probability the Specific Nuclear Project Receives Regulatory Approvals • Project Implementer Ability to Meet Regulating Entity Expectations • Project Implementer Capability (c) • Regulating Entity Confidence in Project Implementer • State/Local Economic Benefits of Specific Nuclear Project Received • Specific Nuclear Project Cost Overrun • Specific Nuclear Project Expected Budget Available • Support from Non-Host State Cong Reps with Specific Need for Specific Nuclear Project • Support from Non-Host State Cong Reps without Specific Need for Specific Nuclear Project • Tangible SNM Benefit • Time to Consider Regulatory Approvals Application	• R(S/N)1: Stakeholder Consensus vs. Political Controversy Loop • R(S/N)2: Stakeholder Consensus vs. Re-Election Loop • R(S)3: Political Benefit from Project Support Loop • R(S/N)4: Project Implementer Expectations & Approvals Loop • R(S/N)5: One-of-a-Kind Uncertainty vs. Mistakes Loop • R(S/N)6: Learning vs. Continued Operations Loop • R(S/N)7: Willingness to Pay vs. Overrun Loop • R(S/N)8: National Willingness to Pay vs. Controversy Loop • R(S/N)9: State/Local Benefits vs. Political Controversy Loop • R(S/N)10: Cost Overrun vs. Non-Host State Support (with need) Loop • R(S/N)11: Cost Overrun vs. Non-Host State Support (without need) Loop • R(S/N)12: Accumulated Benefit & Expansion Loop • B(S/N)1: Peer Pressure vs. Cost Overrun Loop • B(S/N)2: Accumulated Benefit vs. Operational Limits Loop
(c) indicates a 'connecting variable/feedback loop' (a variable/feedback loop present in more than one CLD) **(i)** indicates an 'initializing variable (a variable with no causal input)		

STAKEHOLDER ENGAGEMENT MANUAL

Built upon the concept that stakeholder acceptance is a dynamic, emergent system property logically reflected in the CLDs, explained above, the purpose of the Stakeholder Engagement Manual is two-fold. First, the final version of the manual can be used as the foundation for additional educational material generated to help with knowledge transfer of this theory and model of stakeholder acceptance. Second, versions of this manual can be given to operating nuclear facilities seeking to improve stakeholder acceptance for their ongoing projects. This could be done in exchange for access to the results from its implementation.

The Stakeholder Engagement Manual first identifies the essential elements of stakeholder engagement, which include: personal benefit, cognitive conception of risk, personal framing, trust asymmetry, social trust & credibility in the project implementer, core values, news media & popular culture and political dynamics.

The Manual continues to illustrate the guiding principles for building strong stakeholder relationships. These **Stage 1** (**Develop an Engagement Strategy**) principles are designed to help a project manager develop an engagement strategy by defining project objectives and gaining a deeper understanding of project requirements in order to reflect the constraints of its environment. While it is important to understand that every project is different, these principles provide a basic framework from which to develop strategies for stakeholder engagements and can be used to the degree feasible possible given project schedule and cost constraints.

The Manual then offers additional **Stage 2** (**Build, Monitor and Maintain Stakeholder Relationships**) principles to refine engagement objectives as stakeholder relationships develop and more is learned about each stakeholder's values and opinions. These areas of emphasis are intended to focus the use of resources fostering project relationships and can be used in conjunction with the engagement strategy principles to build a plan to foster mutual trust and strengthen project relationships over the project's lifetime.

The Manual ends by offering two sets of **Stage 3** (**If Needed, Recover the Relationship**) principles because the variability and unpredictability of stakeholder responses to various relationship stresses are complicated, requiring a high level framework of proactive and reactive responses to restore stakeholder relationships.

The Manual ends with a call to project managers to assign stakeholder acceptance as a project performance requirement – complete with adequate resources and authority to effectively engage stakeholders. Stakeholder engagement is as much an art as it is a science, and requires understanding the process of engaging stakeholders and their dynamic relationships. Every project is unique, and will have its own complications, but the project implementer can increase the likelihood project success, or at least mitigate risk, by building – and maintaining – strong stakeholder relationships. For more, please see [10] [9].

WASTE ISOLATION PILOT PLANT (WIPP) CASE STUDY SUMMARY

The combination of its unique developmental history, early operational safe and successful operations, and recent occupational safety (e.g., February 5, 2014 underground truck fire) and environmental contamination concerns (e.g., February 14, 2014 radiation alert registered in continuous air monitors) have made WIPP a timely case study for an emerging theory and model on stakeholder acceptance for socially controversial projects. The Waste Isolation Pilot Plant (WIPP) is a 16-square mile site with the underground portion lying 2,150 feet below the surface, in the middle of a 3,000 foot thick salt deposit located in approximately 26 miles away from Carlsbad, New Mexico. WIPP's mandate is permanently to store transuranic waste from DOE defense-related nuclear activities. WIPP was designed and constructed according to a planned operational lifetime expected to end between 2023 and 2030 and has been certified by the NRC and the EPA for use over a period of 10,000 years. From the reception of its first waste shipment in 1999 to early 2014, WIPP had successfully operated for 15 years and maintained high levels of acceptance and support across various stakeholders. Support for, experiences with and perceptions of WIPP were so high, that the Presidentially appointed Blue Ribbon Commission on America's Nuclear Future called WIPP a 'model' of consent-based operations [13] and Carlsbad itself was lobbying the DOE to expand WIPP's mission to include storing commercial nuclear waste.

Applying our theory and model to describe the events at WIPP resulted in several interesting lessons learned. **First**, our models suggest that alignment between different levels of stakeholder is necessary for project acceptance – with WIPP showcasing that local and national support overcame state level opposition to the facility during initial discussions and local and state support overcoming national opposition after the February 2014 incidents. **Second**, our model suggests a need for intentional and timely communications to improve stakeholder acceptance. This is validated by WIPP's regular online updates and bi-monthly town hall meetings starting in early March 2014 after several weeks of ineffective and vague communications. **Third**, our model suggests that accumulated benefits of a socially controversial project change the dynamics of stakeholder acceptance. Here, WIPP's successful operation have built significant amounts of local, state and national political capital (e.g., jobs created nuclear waste stored), making oppositional arguments that less potent. **Lastly**, our model suggests the existence of an independent, 'honest broker' is vital to stakeholder management. Much of WIPP's early success is credited to the Environmental Evaluation Group (EEG) – a third party oversight committee mandated by the state of New Mexico to regularly evaluate WIPP's design and operations in order to ensure public and environmental safety. It was disbanded in 2004. Our model suggests that the subsequent lack of such an entity seriously eroded stakeholder acceptance of a project – which seems accurate given the WIPP's lack of any such entity responsible for this role since 2010, and the negative effects of the events of 2014.

In summary, the WIPP case study helped to refine and validate our theory and model of managing stakeholder acceptance for socially controversial projects – including the importance of **initiating**, **maintaining** and (if need) **recovering** stakeholder acceptance. Per the Golay-Williams Model, WIPP's levels of stakeholder acceptance during its first 15 years of operation seem to have been (at best) unintentionally and (at worst) unwittingly initiated and maintained. So when it is suggested that local community support is instrumental in getting WIPP open and will be instrumental in getting WIPP open again, the Golay-Williams Model provides a framework to design and build enduring structures and strategies to increase acceptance across WIPP's many stakeholders. For more, please see [5] [4].

NUCLEAR POWER PLANT #1 (NPP#1) CASE STUDY SUMMARY

Nuclear power plants provide clear examples of socially controversial projects, as they supply a clear benefit to society (e.g., electricity generation)—that also has tangential advantages (e.g., low carbon emissions)—that are shrouded in societal anxiety over how that benefit is produced (e.g., the use of nuclear and radioactive materials). As such, some stakeholders may be ardent opponents who are completely against nuclear power, some may be nuclear unequivocal advocates and most will be somewhere in the middle. For this reason, a case study analysis of the Golay-Williams Model was conducted on an active Nuclear Power Plant (NPP) in the U.S. Because NPP has been running for decades and is considered a successful project by the nuclear industry, its stakeholder management protocols were a good benchmark for the Golay-Williams Model. More specifically, the NPP staff is experienced in public outreach, particularly in nuclear public outreach, the same outreach staff has been in place for a long time and the VP for NPP had experience with complex stakeholder management at a prior position in the nuclear industry. This experience across NPP management sharing different organizational rationales certainly helps the NPP manage their stakeholders better.

Themes in NPP stakeholder realities and behavior emerged from the case study data, including: symbiotic relationships (e.g., economic and political connections between NPP and various stakeholders); economic benefit (e.g., increased payrolls, local/state taxes and secondary economic effects); augmented capabilities (e.g., the 'spillover' of highly-skilled craftsmen from the NPP to other local engineering projects); human employee visibility (e.g., public outreach and community volunteerism); NPP contact response time (e.g., perception of NPP attentiveness and responsiveness to stakeholder concerns); and, trust safety and fear (e.g., interdependent reactions amidst spikes in stakeholder concern over NPP activities).

For additional analysis, three major public outreach campaigns conducted by NPP were selected for study, including a license renewal process, the replacement of their steam generators and the expansion of their nuclear waste storage facility. These campaigns all involved getting sufficient stakeholder support to proceed or the NPP would be forced to shut down. Across these three campaigns, the NPP used common strategies based upon two principles: use of a single communicator is not a sustainable plan for generating public trust and the path to approval is never linear. Other elements of NPP's strategies included: minimizing flooding stakeholders with educational materials; demonstrating plant safety quickly (e.g., helping to alleviate negative 'radiation attitudes' within stakeholders); information distribution hierarchy (e.g., higher level stakeholder receive quantitatively and qualitatively different NPP information); remaining economically viable; and increasing stakeholder familiarity with plant operations.

Conclusions from this case study provide several insights for the Golay-Williams Model. First, the model accurately explains a majority of the stakeholder engagement activities of NPP and illustrates stakeholder behaviors that would otherwise have been missed. Second, the very complex, time sensitive, and intertwined relationships that keep the NPP alive emphasizes why a stakeholder collation is necessary for project success. Third, a major advantage of the Golay-Williams Model is that it provides a way to think about stakeholder management and to identify particular types of stakeholder dynamics that may determine acceptance. Lastly, the Golay-Williams Model describes the benefits of NPP's proactive stakeholder engagement protocols and would help the NPP maintain its current high levels of stakeholder acceptance—even in the face of a safety incident, political impasse, or economic unviability. For more, please see [7] [4].

HYDRAULIC FRACTURING CASE STUDY SUMMARY

Hydraulic fracturing (popularly referred to as 'fracking') is a technological and procedural breakthrough allowing natural gas trapped underneath (primarily southern and western) New York and (western and central) Pennsylvania potentially accessible. Fracking involves injecting large volumes of water laced with proprietary chemical mixtures at high pressures into the bedrock. Estimates in 2011 of recoverable natural gas in the Marcellus Shale were around 500 trillion cubic feet—the equivalent of 86 billion barrels of oil and enough electricity for 60 million homes across the nation. Despite similarities in geography, demographics and need for economic development, Pennsylvania and New York have taken nearly diametrically opposed positions toward fracking.

From the early 2000s, Pennsylvania was an early adopter, continued supporter and economic beneficiary of fracking (and unconventional oil and gas extraction writ large). New York also showed early enthusiasm with fracking – and the associated economic development opportunities for the upstate region – but also held long-standing anxieties and hesitancies (ostensibly) regarding environmental risks and drinking water contamination concerns. Moving beyond traditional arguments based on public opinion polls and community outreach, the Golay-Williams Model argues that the Pennsylvania/New York divide on fracking is explained by behaviors and actions of state level stakeholders that have influenced individual, local and federal dynamics for accepting fracking. The same positive and negative stakeholder dynamics are present in both New York and Pennsylvania but the Golay-Williams Model suggests a specific underlying structure and explicit causality of a few key decisions at a few key times that initiated different feedback processes and resulted in the disparate response present today.

For this study the Golay-Williams Model describes the current, orthogonal views of fracking between Pennsylvania and New York through combinations of its feedback loops [6]. For example, the Stakeholder Consensus vs. Political Controversy Loop (R(S/N)), Social Framing & Tradeoff Loop (R(L)4) and Perceived Benefit vs. Implementation Loop (R(L)2) interact to describe the how the opinion of A-list celebrities in New York City (not near fracking areas), growing general doubt or opposition to fracking (by those not directly affected) and state level decisions against fracking (e.g., the moratorium and eventual ban) lead to the 'Santa Fe Effect' [2] and a key tipping point the seems to emerge in explaining the New York case. Similarly, the Perceived Benefit vs. Implementation Loop (R(L)2), Tradeoff vs. Risk Loop (R(L)3) and Social Trust vs. Benefit Loop (R(L)11) combine to explain how accumulated economic, political and infrastructural benefits result in the lack of powerful local outrage during incidents at fracking sites (e.g., the Atgas 2H well incident) because the more benefit associated with an activity, the greater the leeway in responding to negative events.

Conclusions from this fracking case study regarding the Golay-Williams Model can be ascertained. First, The Model accurately describes a majority of the actions and behaviors observed in New York and Pennsylvania regarding fracking. Second, the three phases of stakeholder acceptance espoused by the Golay-Williams Model—initiation, maintain and (if needed) recover—were successfully navigated in Pennsylvania, but not in New York. Third, this state-to-state comparison highlights the importance of state-level stakeholders and structural dynamics as 'force-multipliers' in influencing acceptance levels for fracking projects. Lastly, this case study demonstrates that the Golay-Williams Model for Stakeholder Acceptance is useful for mitigating common perceptions of ambivalence or skepticism about fracking. For more, please see [6] [3].

CAPE WIND PROJECT CASE STUDY SUMMARY

The New England offshore wind project (OWP) is an offshore wind energy project proposed by Cape Wind Associates (CWA), a Boston-based energy company. Consisting of 130 wind turbine generators (WTGs) of 3.6 MW of capacity each, the project would be located in Federal waters off the coast of Cape Cod, Massachusetts, on Horseshoe Shoal in Nantucket Sound, approximately 5.2 miles (8.4 km) away from the nearest shore. Despite generating a coalition of strong stakeholder support that helped OWP navigate various challenges to initiating operations, in January 2015 the two utilities who had agreed to buy the electricity produced opted out of those agreements. Without these purchasing agreements, OWP was unable to attract investors and although the project developers have not abandoned the project to date, this financing issue has been a major setback for a project that was gaining stakeholder support over its 15 years of development. In addition, in April 2016 the Massachusetts Energy Facilities Siting Board (MAEFSB) declined to issue OWP a permit extension for the installation of the transmission line that would connect the project to the power grid, further dampening the likelihood of project success.

The case study data identified several key Golay-Williams Model variables that played significant role in shaping the stakeholder attitudes toward OWP. For example, because OWP was the first offshore wind farm proposed in the U.S., the low popular familiarity with the technology increased the sense of uncertainty. This, in turn, allowed negative speculation on the project to be accepted across stakeholders and made regulating authorities timid and precautious. Further, the case study data illustrated how the 'technological attitudes' related to OWP trended positively over the life of the project, primarily driven by positive trends in the 'personal sense of uncertainty' and 'perceived personal control' variables. When these trends were coupled with a decreasing trend in the 'negative personal framing' model variable, OWP stakeholder 'technological attitudes' began to strongly support the project. In simple terms, the trend in this variable contributed to a re-enforcing loop that increased the Perceived Personal Control and the Technological Attitudes.

Conclusions regarding the Golay-Williams Model can be elicited from this case study. First, the model did accurately describe the stakeholder dynamics that helped shaped the OWP development process for the better part of 15 years. The Golay-Williams Model does a good job of capturing the 'initial conditions' (such as low familiarity with the technology and stakeholder empowerment), their effects that they had in shaping the stakeholder dynamics, how the increase in perceived transparency translated into a stronger sense of social trust in the project implementer and how stakeholder dynamics were captured by the technological attitudes and the stakeholder acceptance, resulting in an overall positive trend throughout the time of development of the project. Second, emphasizing familiarity with technology and increasing stakeholder empowerment are more effective mechanisms for overcoming stakeholder resistance stemming from limited technical understanding than traditional education campaigns. Third, the case study clearly indicates the importance of developing stakeholder coalitions, as the lack of supportive stakeholder coalition could have led the OWP's cancellation years earlier. Fourth, the importance of timely, targeted and accurate communications with stakeholders was demonstrated when OWP was able to turn the discussion about the project into a discussion about the right way of doing government, about democracy, about hypocrisy in the climate change debate and about the power of the elite. Lastly, stakeholder acceptance is a necessary, but singularly insufficient characteristic for project success—as indicated by OWP's highly successful stakeholder engagement program but inability to continue due to financial limitations. For more, please see [8] [3].

EMPIRICAL STUDY SUMMARY

The Golay-Williams Model was developed on the premise that the dynamics underneath stakeholder acceptance are similar across socially controversial projects—and that project implementers across such projects face similar challenges. For this study, the technical and implementation details will vary across energy projects, but the case studies suggest that the model provides a framework from which to understand stakeholder dynamics. Specific key insights and lessons learned from each of these care studies supporting the Golay-Williams Model are summarized in Table 5, below.

Table 5. Summary of key insights from case studies evaluating the Golay-Williams Model across a range of socially controversial energy projects.

Case	Energy-Type	Golay-Williams Applicability	Insights & Lesson Learned
NPP #1	Nuclear (Power)	High	Importance of pro-active stakeholder engagement to increase acceptance
			Need to clearly map complexity of stakeholder landscape
			Success of NPP continued operations significantly enhanced by high levels of stakeholder acceptance
Offshore Wind Energy	Wind Power	High	Importance of stakeholder coalitions
			A project can do all of the 'right things' for stakeholder acceptance & still not succeed as a project
			Ability of stakeholder dynamics to change opposition to acceptance (and support)
WIPP	Nuclear (Waste)	High	Accumulated financial/local infrastructure/ political benefits 'masked' the stakeholder dynamics underneath pre-2014 acceptance levels
			Importance of alignment between local (e.g., Carlsbad Mayoral Nuclear Task Force), state (e.g., NM Environmental Department) and national (e.g., NM Senators) stakeholders
			Influence of an 'honest broker' (e.g., EEG) to increase acceptance across stakeholders
Fracking	Natural Gas	Medium-High	State versus state comparison illustrates role of state-level stakeholders as 'force-multipliers'
			Importance of alignment of stakeholder values across stakeholder levels

The conclusions of these case studies were consistent in their acknowledgment that the Golay-Williams Model accurately explained the stakeholder dynamics observed in the energy project and each case also identified several dynamics or trends that were unique and not shared among other cases—these are summarized in Tables 6 and 7, respectively.

Table 6. Summary of case study data support for the accuracy of the Golay-Williams Model structure & conceptualization of stakeholder acceptance.

Element of Golay-Williams Model Structure	NPP	Cape Wind	WIPP	Fracking
Explains Stakeholder Dynamics observed in the Case	X	X	X	X
Dynamic Nature of Stakeholder Acceptance	X	X	X	X
3 Phases of Stakeholder Acceptance	X	X	X	X
Tri-level Conception of Stakeholder Acceptance	X	X	X	X
Support of the Stakeholder Engagement Manual	X	X	X	X

Table 7. Summary of themes emerging from case study analysis of the Golay-Williams Model

Emergent Golay-Williams Model Themes	NPP	Cape Wind	WIPP	Fracking
Limited technical understanding of a project is better overcome by increased familiarity versus education campaigns	X	X	X	X
Importance of timely communication between project implementer & stakeholders	X	X	X	
Need for value alignment between stakeholder levels		X	X	X
Importance of stakeholder coalitions	X	X	X	
Project opponents can employ stakeholder dynamics to their advantage		X		X
Role of 'honest broker' to mitigate social controversy			X	X
Role of state-level stakeholders as 'force-multipliers'			X	X

Working the qualitative interview and case study data from a 'grounded' perspective [27] helps ensure that that Golay-Williams model includes well-developed, conceptual relationships that explain the variance in the data for, broad influencing conditions of, and identification of significant conclusions relating to stakeholder acceptance of nuclear facilities. The better the data fits the theoretically developed causal mechanisms, the more likely it can be expected for the same causal mechanisms in similar conditions or circumstances to have the same results; in other words, the better the G-W model explains the stakeholder acceptance of socially controversial projects, the more likely the model would be useful for understanding and improving stakeholder acceptance at nuclear facilities with similar surrounding circumstances. Here, the researchers illustrate that pattern matching (seeking consistency between empirical and theoretical patterns), explanation building (explicitly stating causality about 'how' or 'why'), logical models (examining a theory of change by comparing observed and expected outcomes) [28] and the iterative process of locally and inclusively integrating mini-theories indicated that the data support the theoretical claims underpinning the Golay-Williams Model.

CONCLUSIONS

As the demand for energy increases, so will the need for large-scale energy projects. This increased societal need will continue to experience friction with the social popularity of NIMBYism—resulting in increased levels of social controversy surrounding such projects. As such, initiating, maintaining and (if needed) recovering stakeholder acceptance of such projects will similarly increase in importance. The Golay-Williams Model—built on a solid foundation across relevant literatures, consistent with interview data and supported by case study analysis across energy projects—provides a mechanism to describe stakeholder dynamics and prescribe engagement strategies to increase stakeholder acceptance in support of completing project goals. Understanding that key phenomena emerge from the interactions of variables across three levels of stakeholders marks a significant shift from traditional approaches to stakeholder management. Though specific mechanisms to improve stakeholder acceptance may look similar to those produced by current approaches, those offered by the G-W Model provide traceability to key social phenomena and generate better engagement actions and strategies. An example concerns the practice of encouraging NPP employees to live in nearby population centers, and to serve as ambassadors for the plant who can humanize the plant projects and help to assuage fear—even if doing so requires longer, more inconvenient daily commutes to work.

In addition, the results from our research project supports the main research objectives. First, stakeholder acceptance is more accurately modeled a 'state of being' rather than an effective communication strategy or education campaign. As evidenced in the NPP case study [7], the stakeholder engagement activities taken proactively serve to keep a majority of (or, at least key) stakeholders accepting of and supporting the projects. Similarly, the inability of Cape Wind—despite high levels of stakeholder support and adhering to several of key stakeholder engagement actions suggested by the Williams-Golay Model—to become a viable project [8]. In the former, the socially controversial project was able to stay in a 'state of being' where stakeholders accepted its operations, while the 'state of being' in the latter was ultimately misaligned with stakeholder acceptance [3].

The results from our work also support the assertion that stakeholder acceptance a dynamic, system-level characteristic of socially controversial projects. For example, despite being hailed as a 'model of consent,' the high levels of stakeholder acceptance of the WIPP may be misleading and should not rely on accumulated benefits alone to maintain desired levels of stakeholder acceptance. On one hand, it tempers shifts toward declining stakeholder acceptance. On the other, it can also mask other dynamics that are working to undermine stakeholder acceptance. The fracking case study clearly illustrates the usefulness of this dynamic framework, as the same stakeholder dynamics can be used by a project implementer for increasing stakeholder acceptance (e.g., Pennsylvania's response to fracking the Marcellus Shale) or by the opposition to decrease it (e.g., New York's response to fracking the Marcellus Shale) [3].

Lastly, comparing the interview data, case study data and cross-case comparison analytical results, there appears to be fundamental differences between stakeholder engagement for nuclear projects versus other energy-related facilities—including differences in initiating, maintaining and recovering acceptance. For example, in comparison to the other technological attitudes, the NPP case study [7] demonstrated a qualitative difference in 'radiation attitudes.' This case study indicates that cognitive differences in individual CLD level variables between 'radiation attitudes' and other 'wind power' or 'fracking' attitudes (e.g., perceived differences in 'socially catastrophic potential' between nuclear power, wind power and hydraulic fracturing) activate feedback loops at a different rate and strength lead to different stakeholder dynamics [3]. Though nuclear and fracking projects face qualitatively similar types of national, state and local opposition, the existence of a clear conscience and popular cultural influences related to the former [4] illustrates one key differentiator—and significant challenge to overcome.

Overall, the consistent trends across four case studies and three types of energy-related projects indicates that the basic tenets of the Golay-Williams Model—namely, that stakeholder acceptance is a dynamic 'state of being' emerging (and balancing) from the interactions of components—are valid and applicable across these types of socially controversial projects. In addition, the differences between the two nuclear-related case studies and the two non-nuclear case studies help identify how the Golay-Williams Model describes how the former is 'different' that than the latter. Further, our research provide generic insights and lessons learned from applying this new model to case studies [2] [3] [4] [5] [6] [7] [8], as well as an associated Stakeholder Engagement Manual to help project implementers operationalize this model [9] [10].

DOE & CONSENT-BASED SITING

Further, the Golay-Williams Modal can support DOE plans to develop 'phased, adaptive, consent-based siting process' for nuclear projects. Mandated by the 2012 Blue Ribbon Commission Report [13] and the Obama Administration's 'Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste' [14] for siting regional nuclear waste repositories, the DOE is currently soliciting feedback on a set of five core questions[6] from across the U.S. to better characterize consent-based siting. Current efforts include the DOE traveling around the country to meet with citizens and request feedback on a set of five core questions to characterize better the requirements for and implementation of consent-based siting [12].

Per the conclusions and lessons offered in this study, the DOE should consider mapping the likely stakeholder landscape to exist for a regional nuclear waste repository, identify key localized dynamics (e.g., concerns over seismic activity or proximity to federally protected lands), designate adequate resources to develop (and maintain) a dynamic stakeholder engagement program (beyond current efforts), work to create a coalition of various stakeholders (e.g., academic, NGOs or grassroots organizations at the local, state and national levels) to support the project from its earliest conception and ensure a multi-faceted campaign is undertaken to account for the aforementioned 'radiation attitudes' hypothesis. The explanatory power demonstrated in the case studies summarized in this study suggest that the Williams-Golay Model of Stakeholder Acceptance for Socially Controversial Projects would be useful in such endeavors. Other energy related projects that would benefit from a similar redesign approach to stakeholder acceptance include DOE's recently unsuccessful attempt at establishing a pilot plant for deep borehole disposal in North Dakota and the introduction of fracking into interested states like West Virgina, Ohio, Michigan and California.

[6] The five questions are: (1) How can the DOE ensure that the process for selecting a site is fair?; (2) What models and experience should the DOE use in designing this process?; (3) Who should be involved in the process for selecting a site, and what is their role?; (4) What information and resources do you think would facilitate your participation?; and, (5) What else should be considered?

FURTHER RESEARCH

Two areas for additional research clearly emerge. First, if the application of the Golay-Williams Model to additional case studies—both past and current. Consider, for example, the recent attempt by the DOE to establish a research and testing site at which to 'drill a test borehole of over 16,000 feet into a crystalline basement rock formation near Rugby, North Dakota' [29]. Despite the support from national (e.g., DOE), state (e.g., University of North Dakota Energy & Environmental Research Center and the North Dakota Department of Trust Lands), the local and state level response was swift, strong and oppositional. Here, a mix of individual (negative associations with Yucca Mountain and the Hanford site), local (feeling that Rugby was 'expendable' and not consulted), state (comments by North Dakota Attorney General opposing nuclear waste dumping in the state) and national (2013 DOE Strategy for the Management and Disposal of used Nuclear Fuel and High-Level Radioactive Waste arguing that permanent repositories are the best option) influences reframed the DOE's argument of economic and technical benefit of the project toward it 'feel[ing] like drilling disguised as a scientific experiment…being railroaded into our community' [30]. Not only was the ND option abandoned, but a similar project proposal to Spink County, South Dakota [30] was rejected in much the same way. Invoking the Golay-Williams Model to evaluate this case—as well others relating to siting nuclear waste facilities in the U.S., the spread of fracking activities to new areas and attempts at siting large-scale renewable energy facilities—would likely yield tremendously useful insights to further refine, validate and demonstrate the capabilities of this model to increase the likelihood of success for socially controversial projects.

The second clear area for future research would be to make operational the Golay-Williams Model. More specifically, research is needed to analyze opportunities for translating our qualitative CLD-based model into a more quantitative 'stock and flow' system dynamics model. More specifically,

> 'Stocks are accumulations. They characterize the state of the system and generate the information upon which decisions and actions are based. Stocks give systems inertia and provide them with memory. Stocks create delays by accumulating the difference between the inflow to a process and its outflow. By decoupling rates of flow, stocks are the source of disequilibrium dynamics in systems' [1, p. 192].

As such, additional investigation is necessary to quantify the current set of (and potentially expanded set of) model variables, as well as mathematically describing the relationships between models and within the various feedback loops (a good start is offered in Appendices D-F). In additional to providing more quantitative output data, such a (set of) stock and flow system dynamics models could be the backbone for a 'Stakeholder Acceptance Flight simulator.' Such a capability could serve the dual purposes of allowing a project implement experiment different stakeholder engagement strategies on their particular set of stakeholders and serve as a training tool for developing next generation stakeholder management professionals.

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JOURNAL ARTICLES

- Golay, Michael and Adam D. Williams. (2016) 'The Path to Approval is Never Linear: A System-Theoretic, Dynamic Model on Stakeholder Management for Socially Controversial Engineering Projects,' *IEEE Transactions of Engineering Management,* (In preparation).

- Golay, Michael and Adam D. Williams. (2016) 'Dynamic & Design-Critical: A new perspective for stakeholder management for socially controversial engineering projects,' *Journal of Engineering and Technology Management,* (In preparation).

- Golay, Michael and Adam D. Williams. (2016) 'Social controversy is not if, but when—A system-theoretic, dynamic model for stakeholder management for socially controversial engineering projects,' *Energy Policy,* (In preparation).

- Golay, Michael, Adam D. Williams and Karen Dawson. (2016) 'Overcoming Waste, Weapons & Wardens: How to improve stakeholder acceptance for nuclear power projects,' *Progress in Nuclear Energy,* (In preparation).

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APPENDIX A: RESEARCH TEAM

Faculty Name	Project Role	Academic Department	Years on Project
Michael Golay	Primary Investigator	Nuclear Science & Engineering	2012-2016
Michael Fischer	Subject Matter Expert	Anthropology	2012-2013
Student Name	**Education Level**	**Academic Department**	**Years on Project**
Adam Williams	PhD	Engineering Systems Division	2012-2016
Ekaterina Paramonova	MS	Nuclear Science & Engineering	2013
Aditi Chandra	MS	Nuclear Science & Engineering	2013-2014
David Walsh	MS	Engineering Systems Division/ System Design & Management	2014-2015
Adrian Laws	MS	Engineering Systems Division/ System Design & Management	2014-2015
Sebastian Luque	MS	Engineering Systems Division/ System Design & Management	2015-2016
Karen Dawson	MS	Nuclear Science & Engineering	2015-2016

APPENDIX B: COMPREHENSIVE REFERENCE LIST

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APPENDIX C: IDENTIFICATION OF KEY PHENOMENA & BEHAVIORS FOR STAKEHOLDER ACCEPTANCE

The following is a list – with brief explanation – of the relevant behavioral dynamics associated with attitude formation and determination of stakeholder acceptance levels phenomena.

- The existence of a '**system**' of social, organizational, technical and political influences that can **either reinforce or negate individually developed beliefs** (e.g., a system that, if understood, could help influence individual radiation attitudes in desired directions) (Sterman 2000; de Weck, et al 2011)
- the **differing perspectives of the nuclear acceptance**: In general when it comes to nuclear debates, experts (or highly educated stakeholder groups) see 'solvable technical problems' but the public and/or policy-makers see an 'intractable policy issue.' This impasse greatly influences the arguments used to support and oppose nuclear-related endeavors, often attempting to convert a stakeholder with a differing perspective using the wrong kind of argument (e.g., 'There are no benefits in Santa Fe [New Mexico] from economic activity in Carlsbad [New Mexcio, the site for WIPP], and no pain in distrusting people you have never met. Opposition to burying nuclear waste near Carlsbad has been intense in Santa Fe, where nothing from direct experience challenges "better safe than sorry [e.g., only seeing the danger and not seeing potential opportunity]" (Margolis 1997, 132)'
- the role of **perceived vs. objective truth**: given that it is very difficult to define (and communicate) objective truth or set a standard for many of the variables germane to acceptance-related decision making, it is important to account for any different between perception and objectivity. The idea of the gap between perception and objective truth is an important one – where objective truth signifies the existence of a cognitive connection to a complex item (e.g., new nuclear project). In the absence of such a cognitive connection, a range of heuristics is used to reduce the complexity in question to a manageable level, such as availability (Pachur, et al 2012), affect (Finucane, et al 2000; Slovic & Peters 2006) or anchoring & adjustment (Kahneman & Tversky 1979, 1982). Using **differences in cognitive connections** help to capture the important dynamics effects from the gap between objective and perceived truth;

<u>Individual Phenomena:</u>

- a **rigorous model** for the effect of **individual radiation attitudes** on stakeholder acceptance (Chandra 2014)
- understanding the **relationship between supporting nuclear projects as a concept and a specific nuclear facility nearby**: there is misuse of public opinion polls related to nuclear projects by both supporters of and opposition to nuclear projects. The trend, however, is described best as how 'The majority approval also tends to dissipate as the issue moves from general policy at the national level to the actual building of a plant in the respondents' community (Kasperson et al, 1980, 15)'
- the relationship between **operational** and **expected** (or, speculative) **benefits** – especially where the latter has a (seemingly) exponentially short shelf-life (Venables, et al 2009), but the former has a sustainable, increasing shelf-life (e.g., tax incentives, higher pay and better education, per Bezdek & Wendling 2006; enhanced local infrastructure, per Greenberg 2009; more jobs, per Flynn, et al 1993) – and stakeholder acceptance
- the **role of credibility** of the project implementer: over time, the siting of industrial facilities has evolved from 'announce and build' (circa early 1900s until 1970s) to 'announce, build and defend' (1970s to early 2000s) to finally 'CLAMP – concentrating locations at major plants (Greenberg 2009).' The latter is analogous to 'consent-based siting' – which suggests that the role of the project implementer is more important than ever (Fornell 2007)
- A novel, more **nuanced, cognitive conception** of risk resulting from the tradeoff between risk as an opportunity and as a danger. This concept also introduces the idea of 'cognitive inclusion of frequency' of risk as a danger (especially once benefits of a given project begin to accumulate) (Margolis 1996, 1997)

- the **trust asymmetry principle**: in general, bad news has a bigger effect on attitude formation and decision-making than good news. Similarly, trust is difficult to earn and easy to lose while distrust is easy to gain and hard to lose (Slovic 1993; Cvetkovich, et al 2002). Trust can be in relation to a specific technology, facility or company (regulator) operating (overseeing) a specific activity
- the role of '**probability neglect**' in risk assessment: 'when intense emotions are engaged, people tend to focus on the adverse outcome, not on its likelihood. That is, they are not closely attuned to the probability that harm will occur…this phenomenon…produces serious difficulties of various sorts, including excessive worry and unjustified behavioral changes (Sunstein 2002, 62-63)'

Local Phenomena:

- role of **core stakeholder values** in determining or influencing benefit and risk associated with nuclear projects (de Groot, et. al. 2013)
- the importance of **social trust in the project implementer** as another mechanism by which decisions are made with a lack of individual expertise to manage the complexity of a given endeavor (Siegrist, et al 2000), like a new nuclear project
- need to capture the **'snowball' nature of opinion change** (Kasperson et al, 1980, 19): recently, this snowball effect has worked in opposition to nuclear projects. Convincing the right core people within a stakeholder group may be able to generate a pro-nuclear project snowball effect;
- the influence of **popular culture** and **social perceptions** of '**nuclear things**' (especially during the formative years) on radiation attitudes and stakeholder decision making (Weart 1998, 2012; Mahaffy 2014; Zemand & Amundson 2004)

State/Federal Phenomena:

- **Congressional dynamics** on large-scale projects requiring federal financial support or regulatory approval, including the relationships between Congressional representatives of **states hosting** such nuclear projects, **states** with facilities **served** by such nuclear projects and **states not served** by such nuclear projects (WIPP vs. SONGS case studies)

Project Implementer Phenomena:

- the importance of capturing the benefits of '**situational awareness**' from various stakeholder groups while initiating, maintaining and (if needed) recovering acceptance (Preliminary Expert Discussions #1, #3, #4)
- implementing a '**no surprises**' strategy for communication and outreach for stakeholders – especially related decision-makers (Preliminary Expert Discussions, #1, #2, #3, #4)
- the **dynamics associated with 'one-of-a-kind' facility cost** and the (precarious) balance between mistake/mishaps, lessons learned and movement toward normal operations (WIPP vs. NPP case studies)

APPENDIX D: DETAILED CAUSAL LOOP DIAGRAMS FOR THE GOLAY-WILLIAMS MODEL OF STAKEHOLDER ACCEPTANCE FOR SOCIALLY CONTROVERSIAL PROJECTS

The acceptance of new nuclear projects, especially among various stakeholders (e.g., implementer, local decision-makers, local/surrounding communities, national regulators), can be represented as movement among a spectrum of states of acceptance. The models developed in this project illustrate the dynamics that influence this movement based upon relationships between variables and key phenomena (described above in Appendix A). We have used the system dynamics (based upon engineering control that emphasizes the simultaneous interaction of multiple important factors in system feedbacks) to describe the complex behavior of stakeholder acceptance. Model factors are treated as modulating variables affecting the rate of change (quickly or slowly increasing or decreasing) of conserved quantities – that themselves interact non-linearly. Causal loop diagrams (CLD) are graphical representations that illustrate the directionality of relationships between model variables. In a CLD, an arrow illustrates the hypothesized direction of causality, a '+' represents a positive (or increasing) relationship and a '-' represents a negative (or decreasing) relationship.

Fig. B.2 models the individual influences affecting stakeholder acceptance for a new nuclear project. These individual influences are captured in the variable 'Radiation Attitudes' – which represents the comprehensive reflection of personal attitudes related to facilities using ionizing radiation. In this CLD 'radiation attitudes' is both the influenced variable (being increased with a decrease in 'perceived personal risk,' for example) and the influencing variable (with its increase resulting in increased 'personal & social trust in the implementer,' for example). More specifically, if an individual cognitively frames the new nuclear project positively, their tacitly believed narratives about related technologies will be similarly positive, their radiation attitudes will be positive and ultimately reinforce the initial positive cognitive framing.

Fig. B.2 models the local influences affecting stakeholder acceptance for a new nuclear project. These local influences are captured in the variable 'Stakeholder Acceptance' – which represents the extent to which stakeholder groups support a new nuclear project. In this CLD 'stakeholder acceptance' is both the influenced variable (being increased with an increase in 'perceived benefit from project,' for example) and the influencing variable (with its increase resulting in an increased 'social opportunity/danger tradeoff,' for example). More specifically, as social trust increases – via philanthropic or volunteer activities, for example – the magnitude of perceived benefits associated with the new nuclear project (e.g., increased property values) increases, which increases stakeholder group acceptance and ultimately reinforces increasing feelings of social trust.

Fig. B.3 models the state/national influences affecting stakeholder acceptance for a new nuclear project. These state/national influences are captured in the variable 'Probability New Nuclear Project Commences/Continues Operations' – which represents the likelihood that the implementer is allowed to continue progress toward specific new nuclear project operations. In this CLD 'Probability New Nuclear Project Commences/Continues Operations' is both the influenced variable (being increased with a decrease in 'new nuclear project cost overrun,' for example) and the influencing variable (with its increase resulting in an increased 'actual value of the new nuclear project,' for example). More specifically, if the new nuclear project is able to maintain operations, the project increases in value to state and national stakeholders, which decreases public/political controversy associated with supporting the project, increases likelihood of national financial support, decreases potential cost overruns and ultimately reinforces new nuclear project operations.

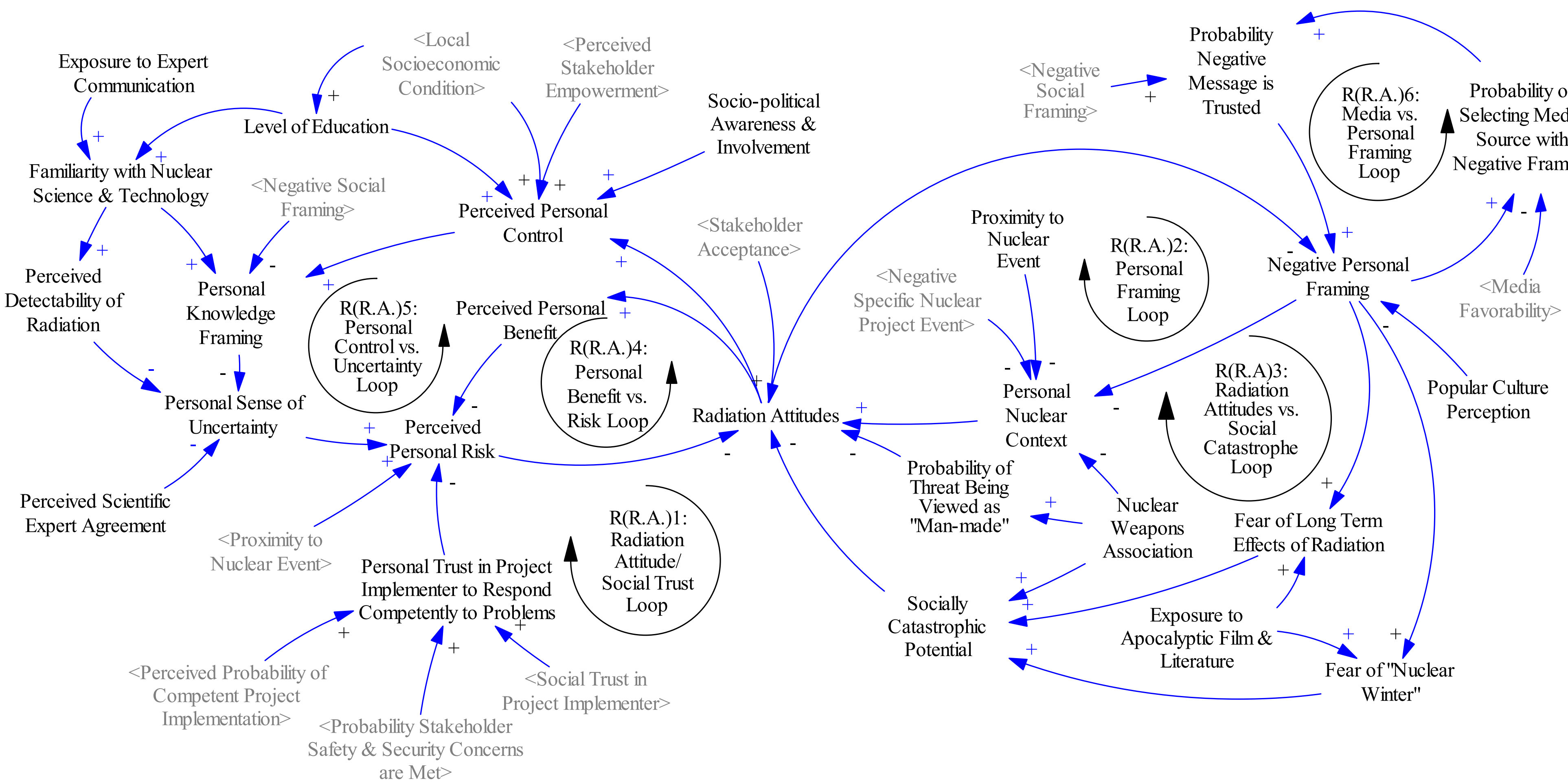

Fig. D.1 – Individual level CLD for stakeholder acceptance of socially controversial projects

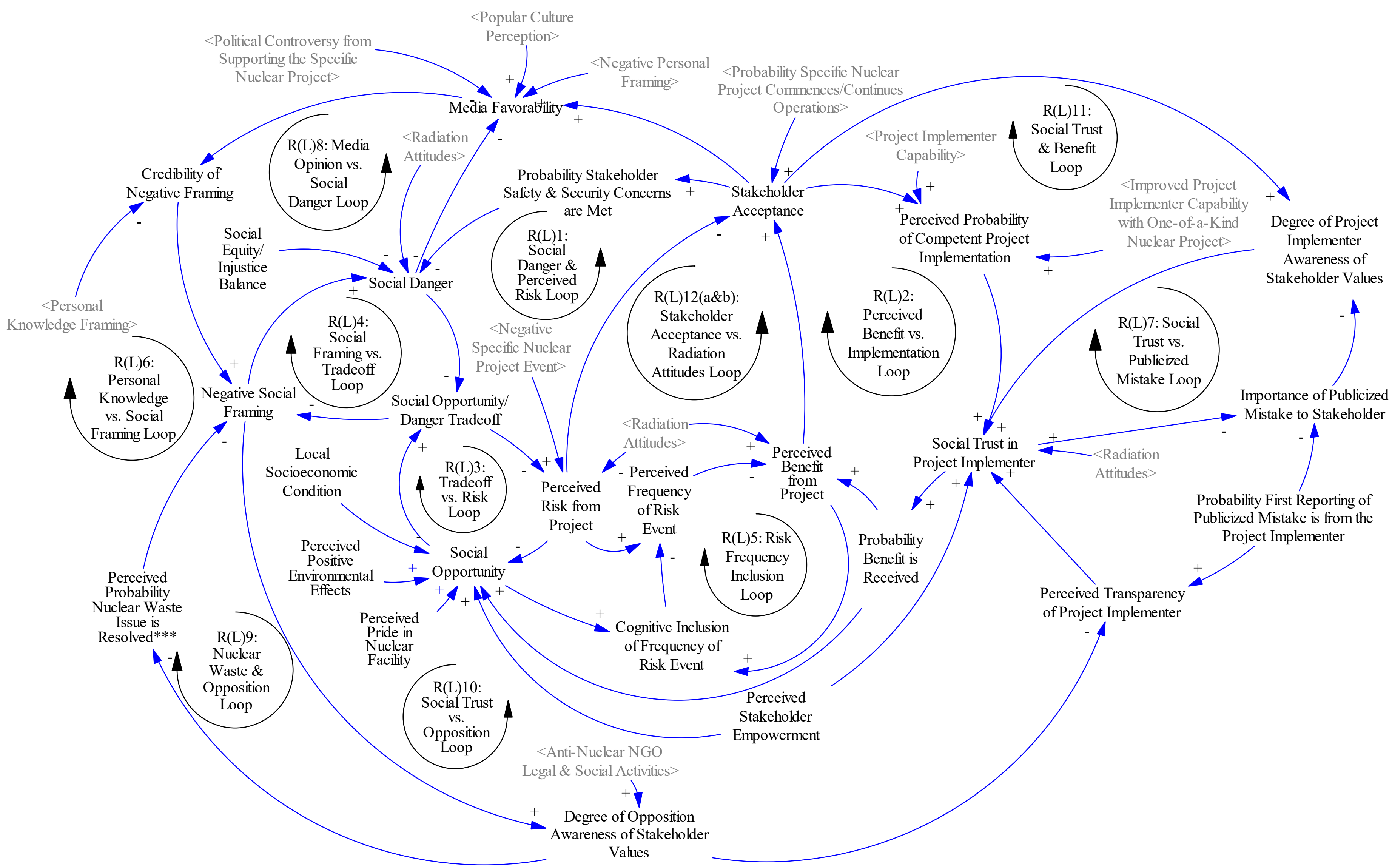

Fig. D.2 – Local level CLD for stakeholder acceptance of socially controversial projects

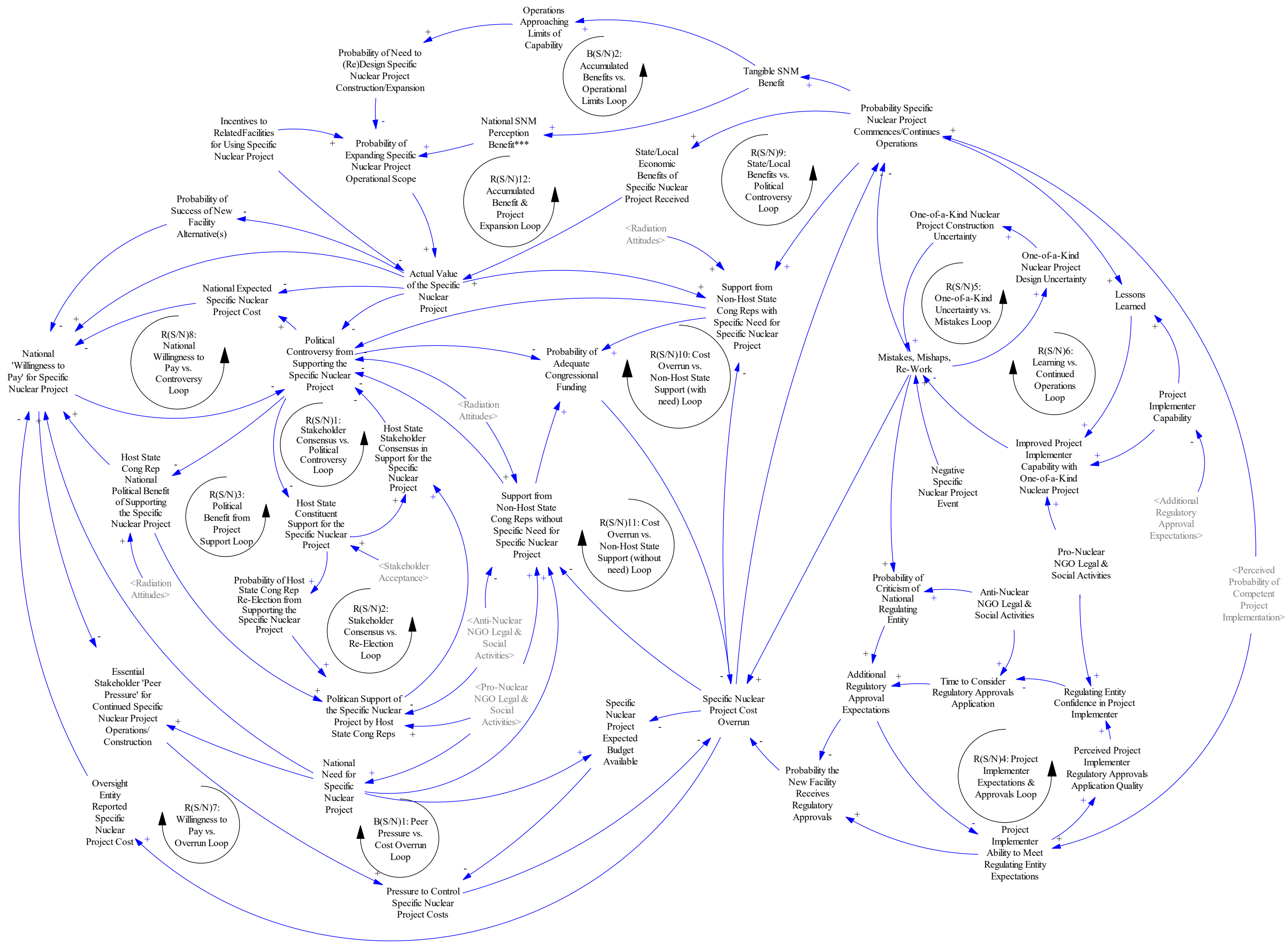

Fig. D.3 – State/federal level CLD for stakeholder acceptance of socially controversial projects

APPENDIX E: DETAILED VARIABLE LIST, DEFINITIONS & QUANTIFICATIONS FOR THE GOLAY-WILLIAMS MODEL OF STAKEHOLDER ACCEPTANCE FOR SOCIALLY CONTROVERSIAL PROJECTS

Table. E.1 – Individual level CLD variable list, definitions & quantifications.

CLD Variable	Stock/Flow Variable Description	Range	Meaning of Lowest Value	Meaning of Highest Value
RADIATION ATTITUDES CLD VARIABLES				
Exposure to Apocalyptic Film & Literature **(i)**	Degree to which movies, books or popular media depicting nuclear technology as the cause of global destruction are encountered by an individual	0 to 1	'0' indicates absolutely no popular media depicting nuclear technology as the cause of global destruction are encountered	'1' indicates extremely high degree of popular media depicting nuclear technology as the cause of global destruction are encountered
Exposure to Expert Communication **(i)**	Degree to which expert talks, research papers, journals or meetings regarding nuclear technology are encountered by an individual	0 to 1	'0' indicates absolutely no expert communications are encountered	'1' indicates extremely high levels of expert communications are encountered
Familiarity with Nuclear Science & Technology	Extent of an individual's understanding of or experience with nuclear science and technology	0 to 1	'0' indicates absolutely no understanding of or experience with nuclear science or technology	'1' indicates extremely high level of understanding of or experience with nuclear science or technology
Fear of "Nuclear Winter"	Fear of global devastation and/or (near) extinction of the human race resulting from a nuclear detonation or extreme negative nuclear event	0 to 1	'0' indicates absolutely no fear of global devastation and/or extinction of the human race resulting from a nuclear-related incident	'1' indicates an extremely high level of fear of global devastation and/or extinction of the human race resulting from a nuclear-related incident
Fear of Long Term Effects of Radiation	Fear that negative human or environmental effects of nuclear technology linger over long time periods (including into future generations)	0 to 1	'0' indicates absolutely no fear that negative human or environmental effects of nuclear technology linger over long time periods	'1' indicates extremely high level of fear that negative human or environmental effects of nuclear technology linger over long time periods
Level of Education	Degree of formal education received by an individual	0 to 1	'0' indicates that an individual is uneducated	'1' indicates that an individual has an extremely high level of education
Negative Personal Framing **(c)**	Degree to which the context an individual uses to understand nuclear technology is negative ['S' Curve @ threshold 'Radiation Attitudes' value]	-1 to 1	'-1' indicates an absolutely positive context an individual uses to understand nuclear technology	'1' indicates an absolutely negative context an individual uses to understand nuclear technology
Nuclear Weapons Association **(i)**	Degree to which the specific nuclear project is associated with nuclear weapons	0 to 1	'0' indicates 0% association of specific nuclear project with weapons	'1' indicates 100% association of specific nuclear project with weapons
Perceived Detectability	Ease with which the presence or	0 to 1	'0' indicates that radiation is perceived as	'1' indicates that radiation is perceived as

of Radiation	existence of radiation can be identified by an individual		highly undetectable	completely (e.g., easily) detectable
Perceived Personal Benefit	Sense of economic, social or environmental advantage an individual associates with nuclear technology	0 to 1	'0' indicates that an individual perceives no economic, social or environmental benefit from nuclear technology	'1' indicates that an individual perceives high levels of economic, social or environmental benefit from nuclear technology
Perceived Personal Control	Degree to which an individual perceives an ability to influence nuclear technology-related projects	0 to 1	'0' indicates that an individual perceives a complete lack of influence over nuclear technology-related projects	'1' indicates that an individual perceives high levels of influence over nuclear technology-related projects
Perceived Personal Risk	Sense of cost/risk (e.g., economic, environmental, or health-effects) associated with nuclear technology	0 to 1	'0' indicates that an individual perceives absolutely no cost/risk associated with nuclear technology	'1' indicates that an individual perceives extremely high levels of cost/risk associated with nuclear technology
Perceived Scientific Expert Agreement **(i)**	Consistency and compatibility between different sources of scientific information regarding nuclear technology	0 to 1	'0' indicates complete disagreement among scientific sources	'1' indicates complete agreement among scientific sources
Personal Knowledge Framing **(c)**	Degree to which new knowledge regarding nuclear technology gained is positive	-1 to 1	'-1' indicates all new knowledge regarding nuclear technology is perceived as negative	'1' indicates all new knowledge regarding nuclear technology is perceived as positive
Personal Nuclear Context	Inherent, tacitly believed narrative about nuclear technology that influences an individual's risk perception and decision-making	-1 to 1	'-1' indicates that the context in which nuclear technology is viewed is completely negative	'1' indicates that the context in which nuclear technology is viewed is completely positive
Personal Sense of Uncertainty	Sense of not knowing, being able to rely on or being completely sure of the benefits of nuclear technology	0 to 1	'0' indicates an individual perceives or experiences absolutely no uncertainty to the benefits of nuclear technology	'1' indicates an individual perceives or experiences extremely high levels of uncertainty to the benefits of nuclear technology
Personal Trust in Project Implementer to Respond Competently to Problems	Extent to which an individual is willing to rely on the Project Implementer to adequately respond to nuclear technology-related problems to ensure safety and security of public interests	0 to 1	'0' indicates an individual is absolutely not willing to rely on the Project Implementer to adequately respond to nuclear technology-related problems	'1' indicates an individual is extremely willing to rely on the Project Implementer to adequately respond to nuclear technology-related problems
Popular Culture Perception **(i) (c)**	Degree to which themes in popular culture refers to nuclear technology as predominantly positive (especially during the	-1 to 1	'0' indicates popular culture themes related to nuclear technology are completely negative	'1' indicates popular culture themes related to nuclear technology are completely positive

	formative years)			
Probability Negative Message is Trusted	Likelihood an individual believes a negatively-framed message regarding nuclear technology as truth	0 to 1	'0' indicates absolutely no belief in negatively-framed messages regarding nuclear technology as truth	'1' indicates absolutely belief in negatively-framed messages regarding nuclear technology as truth
Probability of Selecting Media Source with Negative Framing	Likelihood that a selected source of information frames nuclear technology negatively	-1 to 1	'-1' indicates zero likelihood that source of information selected frames nuclear technology negatively (e.g., all selected sources frame nuclear technology positively)	'1' indicates absolute likelihood that source of information selected frames nuclear technology negatively (e.g., all selected sources frame nuclear technology negatively)
Probability of Threat Being Viewed as "Man-made"	Likelihood nuclear technology viewed as threat (e.g., due to human incompetence, negligence or failure) only created by mankind	0 to 1	'0' indicates nuclear technology absolutely not seen as a threat only created by mankind	'0' indicates nuclear technology absolutely seen as a threat only created by mankind
Proximity to Nuclear Event **(i)**	Physical or psychological distance between an individual and an event regarding nuclear technology	0 to 1	'0' indicates absolutely no connection to an event regarding nuclear technology	'0' indicates extremely close connection to an event regarding nuclear technology
Radiation Attitudes **(c)**	Comprehensive reflection of personal attitudes to radiation or nuclear-related technologies, processes or facilities ['S' Curve @ threshold 'Perceived Personal Risk' value]	-1 t o1	'-1' indicates an extremely negative comprehensive reflection of personal attitudes toward radiation or nuclear technologies	'1' indicates an extremely positive comprehensive reflection of personal attitudes toward radiation or nuclear technologies
Socially Catastrophic Potential	Potential of a nuclear technology-related event to cause a significant number of deaths or injuries over a short period of time	0 to 1	'0' indicates absolutely no potential for nuclear technology to cause a high number of deaths or injuries over a short period of time	'1' indicates extremely high potential for nuclear technology to cause a high number of deaths or injuries over a short period of time
Socio-political Awareness & Involvement **(i)**	Extent of an individual's awareness of surrounding social and political issues, as well as levels of contribution to community affairs	0 to 1	'0' indicates absolutely no awareness of surrounding social and political issues, as well as absolutely no level of contribution to community affairs	'1' indicates extremely high awareness of surrounding social and political issues, as well as extremely high levels of contribution to community affairs

Table. E.2 – Local level CLD variable list, definitions & quantifications.

CLD Variable	Stock/Flow Variable		Meaning of Lowest Value	Meaning of Highest Value
	Description	Range		
LOCAL CLD VARIABLES				
Cognitive Inclusion of Perceived Threat Frequency	Extent to which low frequency of adverse events at nuclear facilities are included in stakeholder group risk determination of a specific nuclear project ['S' Curve @ threshold 'Perceived Benefit from Project' value]	0 to 1	'0' indicates complete rejection of frequency of threatening events from risk determination specific nuclear project	'1' indicates complete inclusion/use of frequency of threatening events from risk determination specific nuclear project
Credibility of Negative Framing	Extent to which negative framing of specific nuclear project is considered credible or trustworthy	0 to 1	'0' indicates negative framing of specific nuclear project is considered 0% trustworthy	'1' indicates negative framing of specific nuclear project is considered 100% trustworthy
Degree of Implementer Awareness of Stakeholder Values	Extent to which the Project Implementer understands the salient values of stakeholder groups	0 to 1	'0' indicates absolutely no understanding of stakeholder group values	'1' indicates absolutely perfect understanding of stakeholder group values
Degree of Opposition Awareness of Stakeholder Values	Extent to which the specific nuclear project opposition understands the salient values of stakeholder groups	0 to 1	'0' indicates absolutely no understanding of stakeholder group values	'1' indicates absolutely perfect understanding of stakeholder group values
Importance of Publicized Mistake to Stakeholder	Extent to which an additional publicized mistake is considered significant to a stakeholder group [Exponential curve vs. 'Probability First Reporting of Publicized Mistake is from the Project Implementer' value]	0 to 1	'0' indicates absolutely no significance of an additional mistake	'1' indicates extremely high level of significance of an additional mistake
Local Socioeconomic Condition **(i) (c)**	Comparison of local social and economic factors to national averages	0 to 1	'0' indicates local economic stagnation (e.g., high poverty, high unemployment - above national averages)	'1' indicates sustained local economic growth (e.g., low poverty, low unemployment - below national averages)
Media Favorability **(c)**	Extent to which media reports are positive, neutral or negative	-1 to 1	'-1' indicates prejudicially negative (e.g., demonizing) tone	'1' indicates prejudicially positive (e.g., canonizing) tone
Negative Social Framing **(c)**	Extent to which the dominant perspective of a stakeholder group toward a specific nuclear	-1 to 1	'-1' indicates that the dominant perspective of a stakeholders group is 100% positive toward a specific nuclear project	'1' indicates that the dominant perspective of a stakeholders group is 100% negative toward a specific nuclear

	project is negative ['S' curve vs. threshold 'Social Opportunity/Danger Tradeoff' value]			project
Perceived Benefit from Project	Comparison of new/old local net benefit from specific nuclear project ['S' curve vs. threshold 'Probability Benefit is Received' value]	-1 to 1	'-1' indicates complete loss of net benefit (e.g., decreased property values & tax revenue, increased unemployment) from specific nuclear project	'1' indicates significant gain of net benefit (e.g., increased property values & tax revenue, decreased unemployment) from specific nuclear project
Perceived Frequency of Risk Event	Relative expected time between event occurrences	0 to 1	'0' indicates no time between expected events (e.g., continuously occurring events)	'1' indicates infinite time between expected events (e.g., never occurring events)
Perceived Positive Environmental Effects **(i)**	Extent to which nuclear energy has a net positive impact on the environment	-1 to 1	'-1' indicates belief that nuclear energy only has net negative impact on the environment	'1' indicates belief that nuclear energy only has net positive impact on the environment
Perceived Pride in New Specific Nuclear Project **(i)**	Degree of intrinsic value of the specific nuclear project felt by stakeholder group	0 to 1	'0' indicates no intrinsic value from specific nuclear project	'1' indicates absolute intrinsic value from specific nuclear project
Perceived Probability Nuclear Waste Issue is Resolved***	Extent to which the nuclear waste storage and security issue is resolved to satisfaction of stakeholder groups	0 to 1	'0' indicates nuclear waste issue completely unresolved	'1' indicates nuclear waste issue completely resolved
Perceived Probability of Competent Project Implementation **(c)**	Extent to which stakeholder group desired levels of competent project implementation are achieved by the specific nuclear project	0 to 1	'0' indicates absolutely no level of desired competent implementation reached	'1' indicates level of desired competent implementation perfectly reached
Perceived Risk from Project	Probability of fatality and/or environmental devastation from the specific nuclear project	0 to 1	'0' indicates 0% perceived likelihood of fatality and/or environmental devastation	'1' indicates 0% perceived likelihood of fatality and/or environmental devastation
Perceived Stakeholder Empowerment **(i) (c)**	Extent to which stakeholder groups can participate in decisions and actions of the specific nuclear project	0 to 1	'0' indicates absolutely no stakeholder group participation	'1' indicates significant levels of stakeholder group participation
Perceived Transparency of Project Implementer	Extent to which stakeholder group desired levels of Project Implementer transparency are achieved	0 to 1	'0' indicates absolutely no level of desired transparency reached	'1' indicates level of desired transparency has been prefectly reached
Probability Benefit is Realized	Extent to which a stakeholder group realizes	0 to 1	'0' indicates absolutely no realization of publicized benefits	'1' indicates significant realization of publicized benefits

	publicized/expected benefits from the specific nuclear project ['S' Curve @ threshold 'Social Trust in Project Implementer' value]			
Probability First Reporting of Publicized Mistake is from the Project Implementer **(i)**	Extent to which the Project Implementer is first to report to stakeholders	0 to 1	'0' indicates Project Implementer is never the first to report its own (publicized) mistakes	'1' indicates Project Implementer is always the first to report its own (publicized) mistakes
Probability Project Stakeholder Safety and Security Concerns are Met **(c)**	Extent to which stakeholder group desired levels of safety and security are achieved by the specific nuclear project	0 to 1	'0' indicates absolutely no level of desired safety/security reached	'1' indicates level of desired safety/security reached perfectly attained
Social Danger (c)	Cumulative measure of objective risks associated with a specific nuclear project	0 to 1	'0' indicates cumulative measure of objectives risks associated with a specific nuclear project is prohibitively low (e.g., minimum value for input variables considered)	'1' indicates cumulative measure of objectives risks associated with a specific nuclear project is significantly high (e.g., maximum value for input variables considered)
Social Equity/ Injustice Balance **(i)**	Extent to which dangers associated with specific nuclear project are equally shared by public/stakeholder groups	0 to 1	'0' indicates that all dangers are localized and experienced by a small subset of the public/ stakeholder groups	'1' indicates that all dangers are equally shared and experienced by all of the public/stakeholder groups
Social Opportunity	Cumulative measure of objective benefits associated with a specific nuclear project ['S' curve vs. threshold 'Perceived Risk from Project' value]	-1 to 1	'-1' indicates cumulative measure of objectives benefits associated with a specific nuclear project is viewed only as dangers (e.g., maximum value for input variables considered)	'1' indicates cumulative measure of objectives benefits associated with a specific nuclear project is viewed only as opportunity (e.g., maximum value for input variables considered)
Social Opportunity/Danger Tradeoff	Extent to which stakeholder groups consider a specific nuclear project an opportunity, rather than a danger ['S' Curve @ threshold 'Social Opportunity' value]	-1 to 1	'-1' indicates the results of this tradeoff are only dangers (e.g., even opportunities are perceived as dangerous)	'0' indicates the results of this tradeoff are only opportunities (e.g., dangers don't exist)
Social Trust in Project Implementer **(c)**	Extent to which stakeholder groups are willing to rely on the Project Implementer of a specific nuclear project to make decisions in situations where the group lacks the resources to make a decision	0 to 1	'0' indicates absolutely no trust in the Project Implementer to make decisions	'0' indicates absolute trust in the Project Implementer to make decisions

Stakeholder Acceptance **(c)**	Extent to which stakeholder group supports a specific nuclear project	-1 to 1	'-1' indicates active rejection of (e.g., actively protesting against) a specific nuclear project	'0' indicates active acceptance of (e.g., actively advocating for) a specific nuclear project

Table. E.3 – State/National level CLD variable list, definitions & quantifications.

CLD Variable	Stock/Flow Variable		Meaning of Lowest Value	Meaning of Highest Value
	Description	**Range**		
STATE/NATIONAL CLD VARIABLES				
Actual Value of the Specific Nuclear Project	Cumulative measure of the objective value to a nation/ state of a specific nuclear projects ['S' Curve @ threshold 'State/Local Economic Benefits of Specific Nuclear Facility Received' value]	-1 to 1	'-1' indicates cumulative measure of objective value is absolutely negative (e.g., only prohibitive costs/risks exist)	'1' indicates cumulative measure of objective value is absolutely positive (e.g., no prohibitive costs/risks exist)
Additional Regulatory Approval Expectations	Level of additional license/permit expectations by the national regulator on the Project Implementer	0 to 1	'0' indicates zero additional expectations form national regulator	'1' indicates prohibitive level of additional expectations from national regulator
Anti-Nuclear NGO Legal & Social Activities **(c) (i)**	Extent to which national anti-nuclear entities are acting against specific nuclear projects	0 to 1	'0' indicates no national anti-nuclear NGO actions to delay a specific nuclear project	'1' indicates no national anti-nuclear NGO actions to prohibitively delay or stop a specific nuclear project
Essential Stakeholder 'Peer Pressure' for Continued Specific Nuclear Project Operations/ Construction	Degree to which other stakeholder groups effected by a specific nuclear project actively support/encourage the Project Implementer to do everything necessary to continue project progress	0 to 1	'0' indicates absolutely no encouragement/support of stakeholder groups effected by a specific nuclear project	'1' indicates significant levels of encouragement/support of stakeholder groups effected by a specific nuclear project (e.g., lending political, reputational or financial resources)
Host State Cong Rep National Political Benefit of Supporting the Specific Nuclear Project	Extent to which national political power or influence is gained by supporting a specific nuclear project ['S' Curve @ threshold 'Political Controversy from Supporting the Specific Nuclear Project' value]	-1 to 1	'-1' indicates national political influence comes from absolute rejection of a specific nuclear project	'1' indicates national political influence comes from absolute acceptance of a specific nuclear project
Host State Constituent Support for the Specific Nuclear Project	Extent to which a decision-makers constituents support a specific nuclear project	0 to 1	'0' indicates no constituent support of a specific nuclear project	'1' indicates complete constituent support of a specific nuclear project
Host State Stakeholder Consensus in Support for the Specific Nuclear Project	Extent to which different stakeholder groups hold a common belief in support for a specific nuclear project	0 to 1	'0' indicates no stakeholder group common belief in support of a specific nuclear project among stakeholder groups	'1' indicates complete stakeholder group common belief in support of a specific nuclear project among stakeholder groups
Improved Project	Extent to which a Project	0 to 1	'0' indicates Project Implement absolutely	'1' indicates Project Implement perfectly

Implementer Capability with One-of-a-Kind Nuclear Project **(c)**	Implementer can improve its ability to complete required tasks for progress on a one-of-a-kind nuclear project		unable to improve its ability to make progress on a one-of-a-kind nuclear project	able to improve its ability to make progress on a one-of-a-kind nuclear project
Incentives to Nuclear Facilities for Using Specific Nuclear Project **(i)**	Externally provided financial, reputational or service-based motivation to use the specific nuclear project	0 t o1	'0' indicates absolutely no external motivation is provided to use the specific nuclear project	'1' indicates significant levels of external motivation are provided to use the specific nuclear project
Lessons Learned	Extent to which a Project Implementer makes improvements based on mistakes, mishaps or re-work	0 to 1	'0' indicates absolutely no improvements are made based on mistakes or mishaps	'1' indicates significant improvements are made based on mistakes or mishaps
Mistakes, Mishaps, Re-Work	Events that occur to increase cost or delays schedule of operations at a specific nuclear project	0 t o1	'0' indicates absolutely no events occur that increase cost or delays schedule of operations	'1' indicates events continuously occur that increase cost or delays schedule of operations
National Expected Specific Nuclear Project Cost	Forecast/promised measure of cost to national stakeholder groups for the specific nuclear project	0 to 1	'0' indicates minimally acceptable levels of forecast costs (e.g., political/social capital, subsidies & upfront costs) from specific nuclear project	'1' indicates prohibitive levels of forecast costs (e.g., political/social capital, subsidies & upfront costs) from specific nuclear project
National Need Specific Nuclear Project	Extent to which services provided by the specific nuclear facility are needed for national economic or security purposes	0 to 1	'0' indicates absolutely no national economic or security need for the specific nuclear facility	'1' indicates a significant national economic or security need for the specific nuclear facility
National SNM Perception Benefit***	Extent to which successful operations of a specific nuclear project increase the perception of SNM as nationally beneficial	0 to 1	'0' indicates absolutely no perception of SNM as nationally beneficial	'1' indicates significant perception of SNM as nationally beneficial
National 'Willingness to Pay' for Specific Nuclear Project	Expected value (tangible and intangible) versus expected cost tradeoff for a specific nuclear project	0 to 1	'0' indicates that expected cost is prohibitively greater than expected value resulting in an absolute unwillingness to pay	'1' indicates that expected value is significantly greater than expected cost resulting in an absolute willingness to pay
Negative Specific Nuclear Project Event **(i) (c)**	Any event at a specific nuclear project that adversely effects human or environmental health	0 to 1	'0' indicates absolutely no negative events that adversely effects human or environmental health	'1' indicates negative events that adversely effects human or environmental health occur (or have in the recent past)
One-of-a-Kind Nuclear Project Construction Uncertainty	Extent to which the Project Implementer continues specific nuclear project construction with unknown information/unmade decisions	0 to 1	'0' indicates that all information is known and all decisions are made for the construction of a specific nuclear project	'1' indicates that absolutely no information is known and absolutely no decisions are made for the construction of a specific nuclear project

One-of-a-Kind Nuclear Project Design Uncertainty	Extent to which the Project Implementer continues specific nuclear project design with unknown information/unmade decisions	0 to 1	'0' indicates that all information is known and all decisions are made for the design of a specific nuclear project	'1' indicates that absolutely no information is known and absolutely no decisions are made for the design of a specific nuclear project
Operations Approaching Limits of Capability	Extent to which successful operations of the specific nuclear project accumulates resources close to capacity	0 to 1	'0' indicates that successful operations absolutely do not accumulate resources close to capacity	'0' indicates that successful operations absolutely accumulate resources close to capacity
Oversight Entity Reported Specific Nuclear Project Cost	Extent to which the reported cost of a specific nuclear project is growing	0 to 1	'0' indicates absolutely no cost increase reported	'1' indicates prohibitive levels of cost increase reported
Perceived Project Implementer Regulatory Approvals Application Quality	Extent to which the Project Implementer submits a quality license/permit application	0 to 1	'0' indicates extremely poor quality license/permit submittal	'1' indicates perfect quality license/permit submittal
Political Controversy from Supporting the Specific Nuclear Project **(c)**	Extent to which supporting a specific nuclear project generates a prolonged public debate between stakeholder groups with conflicting opinions	0 to 1	'0' indicates no prolonged public debate between stakeholder groups with conflicting opinions associated with supporting a specific nuclear project	'1' indicates prohibitive levels of prolonged public debate between stakeholder groups with conflicting opinions associated with supporting a specific nuclear project
Politician Support of the Specific Nuclear Project by Host State Cong Reps	Extent to which the host state Congressional representatives publically and legislatively support the specific nuclear project	-1 to 1	'-1' indicates host state Congressional representatives publically and legislatively oppose the specific nuclear project	'1' indicates host state Congressional representatives publically and legislatively advocate for the specific nuclear project
Pressure to Control Specific Nuclear Project Costs	Extent to which internal and external forces influence the Project Implementer to use its budget more efficiently	0 to 1	'0' indicates absolutely no internal or external influences to efficiently use the budget	'1' indicates significant levels of internal or external influences to efficiently use the budget
Pro-Nuclear NGO Legal & Social Activities **(c) (i)**	Extent to which national pro-nuclear entities are acting in support of specific nuclear projects	0 to 1	'0' indicates no national pro-nuclear actions supporting specific nuclear projects	'1' indicates significant levels of national pro-nuclear actions supporting specific nuclear projects
Probability Specific Nuclear Project Commences/Continues Operations **(c)**	Likelihood of the Project Implementer is allowed to continue progress toward specific nuclear project operations	0 to 1	'0' indicates absolutely no likelihood of the Project Implementer is allowed to continue progress toward specific nuclear project operations	'1' indicates extremely high likelihood of the Project Implementer is allowed to continue progress toward specific nuclear project operations
Probability of Adequate	Likelihood specific nuclear	0 t o1	'0' indicates absolutely no likelihood the	'1' indicates extremely high likelihood the

Congressional Funding	project receives adequate Congressional funds to meet construction/operations deadlines		specific nuclear project receives adequate Congressional funds to meet pertinent deadlines	specific nuclear project receives adequate Congressional funds to meet pertinent deadlines
Probability of Criticism of National Regulating Entity	Level of criticism lobbied toward the national regulator regarding a specific nuclear project	0 to 1	'0' indicates no criticism of the national regulating entity regarding a specific nuclear project	'1' indicates prohibitive levels of criticism of the national regulating entity regarding a specific nuclear project
Probability of Expanding Specific Nuclear Project Operational Scope	Likelihood that internal or external forces influence the Project Implementer to expand the original scope of the specific nuclear project operations	0 to 1	'0' indicates absolutely no likelihood that internal or external forces influence an expansion of the original scope of the specific nuclear project	'1' indicates a significant likelihood that internal or external forces influence an expansion of the original scope of the specific nuclear project
Probability of Host State Cong Rep Re-Election from Supporting the Specific Nuclear Project	Extent to which supporting a specific nuclear project increases the likelihood of a politician's re-election	-1 to 1	'-1' indicates increase in politician's re-election with complete rejection of a specific nuclear project	'1' indicates increase in politician's re-election with complete support of a specific nuclear project
Probability of Need to (Re)Design Specific Nuclear Project Construction/Expansio n	Likelihood the Project Implementer needs to (re)design the specific nuclear project to consider operational expansion (often due to scope creep)	0 to 1	'0' indicates absolutely no likelihood the Project Implementer would need to (re)design for operational expansion	'1' indicates extremely high likelihood the Project Implementer would need to (re)design for operational expansion
Probability of Success of Specific Nuclear Project Alternative(s)	Likelihood that facilities that perform similar functions as the specific nuclear project successfully operates (actual and/or perceived)	0 to 1	'0' indicates the success of facilities that perform similar functions is much greater than that success of the specific nuclear project	'1' indicates the success of facilities that perform similar functions is much less than that success of the specific nuclear project
Probability the Specific Nuclear Project Receives Regulatory Approvals	Expected probability of a specific nuclear project receiving a license or permit	0 to 1	'0' indicates absolutely no likelihood of a license/permit being received	'1' indicates absolute likelihood of a license/permit being received
Project Implementer Ability to Meet Regulating Entity Expectations	Extent to which the Project Implementer meets national regulating entity expectations regarding the specific nuclear project	0 to 1	'0' indicates complete lack of the Project Implementer meeting national regulator expectations	'1' indicates perfect achievement by the Project Implementer of national regulator expectations
Project Implementer Capability **(c)**	Extent to which a Project Implementer is capable of completing the required tasks for progressing the specific nuclear	0 to 1	'0' indicates severely insufficient Project Implementer capacity	'1' indicates overabundance of Project Implementer capacity

	project ['S' curve @ threshold 'Additional Regulatory Approval Expectations' value]			
Regulating Entity Confidence in Project Implementer	Extent to which the national regulating entity has confidence in the Project Implementer to successfully operate a specific nuclear project	0 t o1	'0' indicates absolutely zero confidence of the national regulating entity in the Project Implementer to successfully operate a specific nuclear project	'1' indicates absolute confidence of the national regulating entity in the Project Implementer to successfully operate a specific nuclear project
State/Local Economic Benefits of Specific Nuclear Project Received	Extent to which a specific nuclear project economic benefits are received by state and local stakeholder groups	0 to 1	'0' indicates absolutely no economic benefits are received by state and local stakeholder groups	'1' indicates an overabundance of economic benefits are received by state and local stakeholder groups
Specific Nuclear Project Cost Overrun	Extent to which actual costs of completing a specific nuclear project exceed budget projections (actual or estimated)	0 to 1	'0' indicates actual costs of completing a specific nuclear project never exceed budget projections	'1' indicates actual costs of completing a specific nuclear project prohibitively exceed budget projections
Specific Nuclear Project Expected Budget Available	Extent to which the Project Implementer expects sufficient budget to be available to complete the specific nuclear project	0 to 1	'0' indicates that Project Implementer expects extremely limited budget available to complete the specific nuclear project	'1' indicates that Project Implementer expects near limitless budget available to complete the specific nuclear project
Support from Non-Host State Cong Reps with Specific Need for Specific Nuclear Project	Extent to which non-host state Congressional representatives who have a specific need publically and legislatively support the specific nuclear project	0 to 1	'0' indicates absolutely no public and legislative support of the specific nuclear project by non-host state Congressional representatives	'1' indicates unwavering public and legislative support of the specific nuclear project by non-host state Congressional representatives
Support from Non-Host State Cong Reps without Specific Need for Specific Nuclear Project	Extent to which non-host state Congressional representatives who do not have a specific need publically and legislatively support the specific nuclear project	0 to 1	'0' indicates absolutely no public and legislative support of the specific nuclear project by non-host state Congressional representatives with no need for the specific nuclear project	'1' indicates unwavering public and legislative support of the specific nuclear project by non-host state Congressional representatives with no need for the specific nuclear project
Tangible SNM Benefit	Extent to which the state/national SNM benefit is accumulated and countable	0 to 1	'0' indicates absolutely no state/national benefits are accumulated and countable	'1' indicates abundance of state/national benefits are accumulated and countable
Time to Consider Regulatory Approvals Application	Amount of time taken during the license/permit application process (during which the Project Implementer is expected	0 to 1	'0' indicates no additional time taken during the applications process	'1' indicates prohibitive amount of time taken during the applications process (e.g., long enough time to cause accumulated costs to discontinue the project)

	to maintain progress forward on the specific nuclear project) ['S' curve @ threshold 'Anti-Nuclear NGO Legal & Social Actions' value]			

APPENDIX F: DETAILED CLD LOOP EXPLANATION FOR THE GOLAY-WILLIAMS MODEL OF STAKEHOLDER ACCEPTANCE FOR SOCIALLY CONTROVERSIAL PROJECTS

Table. F.1– Individual level CLD loop explanations.

Radiation Attitudes	CLD Explanation	Conceptual Behavior Explained	Phenomena
R(R.A.)1: Radiation Attitude/Social Trust Loop (c)	Increasing '**radiation attitudes**' increases the '**social trust in project implementer' (c)**; increasing '**social trust in project implementer**' **(c)** increases the **'personal trust in project implementer to respond competently to problems**'; increasing **'personal trust in project implementer to respond competently to problems**' decreases the '**perceived personal risk**'; decreasing '**perceived personal risk**' increases '**radiation attitudes**'	• Dynamic relationship between individual beliefs on radiation and stakeholder trust in project implementer	• socio-technical system framework (Sterman 2000; de Weck, et al 2011) • social trust in the project implementer (Siegrist, et al 2000) • trust asymmetry principle (Slovic 1993; Cvetkovich, et al 2002) • credibility of the project implementer (Greenberg 2009; Fornell 2007) • snowball' nature of opinion change (Kasperson et al, 1980, 19) • relationship between supporting nuclear projects as a concept and a specific nuclear facility nearby (Kasperson et al, 1980, 15)
R(R.A.)2: Personal Framing Loop	Increasing '**radiation attitudes**' decreases the '**negative personal framing**'; decreasing '**negative personal framing**' increases the **'personal nuclear context'**; increasing **'personal nuclear context**' increases '**radiation attitudes**'	• Reinforcing influence of misinformation/ negative reporting of nuclear project on risk/ opposition	• credibility of the project implementer (Greenberg 2009; Fornell 2007) • relationship between supporting nuclear projects as a concept and a specific nuclear facility nearby (Kasperson et al, 1980, 15) • perceived vs. objective truth/differences in cognitive connections (e.g., Pachur, et al 2012; Finucane, et al 2000; Slovic & Peters 2006; Kahneman & Tversky 1979, 1982) • popular culture and social perceptions of 'nuclear things' (Weart 1998, 2012; Mahaffy 2014; Zemand & Amundson 2004)
R(R.A.)3: Radiation Attitudes & Social Catastrophe Loop	Increasing '**radiation attitudes**' decreases the '**negative personal framing**'; decreasing '**negative personal framing**' decreases the **'fear of "nuclear winter"**'[or decreases the '**fear of long term effects of radiation**']; decreasing '**fear of "nuclear winter"**' [or decreasing '**fear of long term effects of radiation**'] decreases '**socially catastrophic potential**'; decreasing '**socially catastrophic potential**' increases '**radiation attitudes**'	• Individual fears influence expected social fears and negative outcomes	• rigorous model for individual radiation attitudes (Chandra 2014) • snowball' nature of opinion change (Kasperson et al, 1980, 19) • popular culture and social perceptions of 'nuclear things' (Weart 1998, 2012; Mahaffy 2014; Zemand & Amundson 2004) • probability neglect (Sunstein 2002, 62-63)

R(R.A.)4: Personal Benefit vs. Risk Loop	Increasing '**radiation attitudes**' increases the '**perceived personal benefit**'; increasing '**perceived personal benefit**' decreases the '**perceived personal risk**'; decreasing '**perceived personal risk**' increases '**radiation attitudes**'	• Acceptance varies for individuals with same individual radiation attitude for different nuclear fuel cycle facilities	• relationship between supporting nuclear projects as a concept and a specific nuclear facility nearby (Kasperson et al, 1980, 15) • operational vs. expected (or, speculative) benefits (Venables, et al 2009; Bezdek & Wendling 2006; Greenberg 2009; Flynn, et al 1993)
R(R.A.)5: Personal Control vs. Uncertainty Loop	Increasing '**radiation attitudes**' increases the '**perceived personal control**'; increasing '**perceived personal control**' increases the '**personal knowledge framing**'; increasing '**personal knowledge framing**' decreases '**personal sense of uncertainty**'; decreasing '**personal sense of uncertainty**' decreases '**perceived personal risk**'; decreasing '**perceived personal risk**' increases '**radiation attitudes**'	• Increasing sense of control can offset increasing levels of uncertainty – recent emphasis on 'consent-based siting'	• perceived vs. objective truth/differences in cognitive connections (e.g., Pachur, et al 2012; Finucane, et al 2000; Slovic & Peters 2006; Kahneman & Tversky 1979, 1982) • nuanced, cognitive conception of risk (Margolis 1996, 1997)
R(R.A.)6: Media vs. Personal Framing Loop	Decreasing '**negative personal framing**' decreases the '**probability of selecting media source with negative framing**'; decreasing '**probability of selecting media source with negative framing**' decreases the '**probability negative message is trusted**'; decreasing '**probability negative message is trusted**' decreases '**negative personal framing**'	• Influence of trusted information sources on how messages regarding risk/benefit are received	• perceived vs. objective truth/differences in cognitive connections (e.g., Pachur, et al 2012; Finucane, et al 2000; Slovic & Peters 2006; Kahneman & Tversky 1979, 1982) • snowball' nature of opinion change (Kasperson et al, 1980, 19) • popular culture and social perceptions of 'nuclear things' (Weart 1998, 2012; Mahaffy 2014; Zemand & Amundson 2004)

Table. F.2– Local level CLD loop explanations.

Local CLD	CLD Explanation	Conceptual Behavior Explained	Phenomena
R(L)1: Social Danger & Perceived Risk Loop	Increasing '**stakeholder acceptance**' increases the '**probability stakeholder safety & security concerns are met**'; increasing '**probability stakeholder safety & security concerns are met**' decreases the '**social danger**'; decreasing '**social danger**' increases the '**social opportunity/danger tradeoff**'; increasing '**social opportunity/danger tradeoff**2019 decreases the '**perceived risk from project**'; decreasing '**perceived risk from project**' increases '**stakeholder acceptance**'	• Reinforcing nature of tangible danger on perceived risk	• perceived vs. objective truth/differences in cognitive connections (e.g., Pachur, et al 2012; Finucane, et al 2000; Slovic & Peters 2006; Kahneman & Tversky 1979, 1982) • credibility of the project implementer (Greenberg 2009; Fornell 2007) • nuanced, cognitive conception of risk (Margolis 1996, 1997) • differing perspectives of the nuclear acceptance (e.g., Santa Fe vs. Carlsbad on WIPP (Margolis 1997, 132)
R(L)2: Perceived Benefit vs. Implementation Loop	Increasing '**stakeholder acceptance**' increases the '**perceived probability of competent project implementation**; increasing sense of '**perceived probability of competent project implementation**' increases the '**social trust in project implementer**'; increasing '**social trust in project implementer**' increases '**probability that benefit is received**'; increasing '**probability that benefit is received**' increases '**perceived benefit from project**'; increasing '**perceived benefit from project**' increases '**stakeholder acceptance**'	• Competency and social trust of project implementer reinforces perceived and received benefit	• socio-technical system framework (Sterman 2000; de Weck, et al 2011) • relationship between supporting nuclear projects as a concept and a specific nuclear facility nearby (Kasperson et al, 1980, 15) • operational vs. expected (or, speculative) benefits (Venables, et al 2009; Bezdek & Wendling 2006; Greenberg 2009; Flynn, et al 1993) • credibility of the project implementer (Greenberg 2009; Fornell 2007)
R(L)3: Tradeoff vs. Risk Loop	Increasing '**perceived risk from project**' decreases the sense of '**social opportunity**'; decreasing sense of '**social opportunity**' decreases the '**social opportunity/danger tradeoff**'; decreasing '**social opportunity/danger tradeoff**' increases '**perceived risk from project**'	• Dynamic by which risk is either increasingly seen as an opportunity (and decreasingly as a danger) or vice versa	• nuanced, cognitive conception of risk (Margolis 1996, 1997) • operational vs. expected (or, speculative) benefits (Venables, et al 2009; Bezdek & Wendling 2006; Greenberg 2009; Flynn, et al 1993) • differing perspectives of the nuclear acceptance (e.g., Santa Fe vs. Carlsbad on WIPP (Margolis 1997, 132)

R(L)4: Social Framing vs. Tradeoff Loop	Increasing '**social opportunity/danger tradeoff**' decreases the '**negative social framing**'; decreasing '**negative social framing**' decreases the sense of '**social danger**'; decreasing '**social danger**' increases '**social opportunity/danger tradeoff**'	• Reinforcing effect that perception (influenced by negative framing) can have on tangible danger	• popular culture and social perceptions of 'nuclear things' (Weart 1998, 2012; Mahaffy 2014; Zemand & Amundson 2004) • core stakeholder values (de Groot, et. al. 2013) • 'situational awareness' (P.E.D. #1, #3, #4) • trust asymmetry principle (Slovic 1993; Cvetkovich, et al 2002)
R(L)5: Risk Frequency Inclusion Loop	Increasing '**perceived benefit from project**' increases the '**cognitive inclusion of frequency**'; increasing '**cognitive inclusion of frequency**' decreases the '**perceived frequency**'; decreasing '**perceived frequency**' increases '**perceived benefit from project**'	• As benefits increase, descriptions of associated risks increasingly reference low frequency of occurrence; as benefits decrease, any risk is problematic	• perceived vs. objective truth/differences in cognitive connections (e.g., Pachur, et al 2012; Finucane, et al 2000; Slovic & Peters 2006; Kahneman & Tversky 1979, 1982) • snowball nature of opinion change (Kasperson et al, 1980, 19) • probability neglect (Sunstein 2002, 62-63) • nuanced, cognitive conception of risk (Margolis 1996, 1997)
R(L)6: Personal Knowledge vs. Social Framing Loop (c)	Increasing '**negative social framing**' decreases the '**personal knowledge framing**' **(c)**; decreasing '**personal knowledge framing**' **(c)** increases the '**credibility of negative framing**'; increasing '**credibility of negative framing**' increases '**negative social framing**'	• Facts and 'objective' knowledge can easily be co-opted or overwhelmed by framing of the project	• perceived vs. objective truth/differences in cognitive connections (e.g., Pachur, et al 2012; Finucane, et al 2000; Slovic & Peters 2006; Kahneman & Tversky 1979, 1982) • socio-technical system framework (Sterman 2000; de Weck, et al 2011) • differing perspectives of the nuclear acceptance (e.g., Santa Fe vs. Carlsbad on WIPP (Margolis 1997, 132) • credibility of the project implementer (Greenberg 2009; Fornell 2007)
R(L)7: Social Trust vs. Publicized Mistake Loop	Increasing '**social trust in project implementer**' decreases the '**importance of publicized mistake to stakeholder**'; decreasing '**importance of publicized mistake to stakeholder**' increases '**degree of project implementer awareness of stakeholder values**'; increasing '**degree of project implementer awareness of stakeholder values**' increases '**social trust in project implementer**'	• Illustrates importance of (1) project implementer having a high awareness of what stakeholders consider important and (2) minimizing the potential negative aspects of publicized mistakes	• core stakeholder values (de Groot, et. al. 2013) • 'situational awareness' (P.E.D. #1, #3, #4) • 'no surprises' strategy stakeholder outreach (P.E.D. #1, #2, #3, #4) • rigorous model for individual radiation attitudes (Chandra 2014) • trust asymmetry principle (Slovic 1993; Cvetkovich, et al 2002) • social trust in the project implementer (Siegrist, et al 2000)

R(L)8: Media Opinion vs. Social Opinion Loop	Increasing '**media favorability**' decreases the '**credibility of negative framing**'; decreasing '**credibility of negative framing**' decreases '**negative social framing**'; decreasing '**negative social framing**' decreases '**social danger**'; decreasing '**social danger**' increases '**media favorability**'	• Influence of media opinion on tangible danger and stakeholder acceptance	• popular culture and social perceptions of 'nuclear things' (Weart 1998, 2012; Mahaffy 2014; Zemand & Amundson 2004) • socio-technical system framework (Sterman 2000; de Weck, et al 2011) • snowball nature of opinion change (Kasperson et al, 1980, 19) • core stakeholder values (de Groot, et. al. 2013) • 'situational awareness' (P.E.D. #1, #3, #4) • credibility of the project implementer (Greenberg 2009; Fornell 2007)
R(L)9: Nuclear Waste & Opposition Loop	Increasing '**probability nuclear waste issue is resolved**' decreases the '**negative social framing**'; decreasing '**negative social framing**' decreases the '**degree of opposition awareness of stakeholder values**'; decreasing '**degree of opposition awareness of stakeholder values**' increases '**probability nuclear waste issue is resolved**'	• High level of influence nuclear waste has as the 'crown jewel' of anti-nuclear lobby argument	• snowball nature of opinion change (Kasperson et al, 1980, 19) • trust asymmetry principle (Slovic 1993; Cvetkovich, et al 2002) • social trust in the project implementer (Siegrist, et al 2000) • popular culture and social perceptions of 'nuclear things' (Weart 1998, 2012; Mahaffy 2014; Zemand & Amundson 2004) • socio-technical system framework (Sterman 2000; de Weck, et al 2011)
R(L)10: Social Trust vs. Opposition Loop	Increasing '**social trust in project implementer**' increases the '**probability benefit is received**'; increasing '**probability benefit is received**' increases '**social opportunity**'; increasing '**social opportunity**' increases '**social opportunity/danger tradeoff**'; increasing '**social opportunity/danger tradeoff**' decreases '**negative social framing**'; decreasing '**negative social framing**' decreases '**degree of opposition awareness of stakeholder values**'; decreasing '**degree of opposition awareness of stakeholder values**' increases '**social trust in project implementer**'	• Opposing viewpoints gain salience/merit as stakeholders lose trust in the project implementer	• credibility of the project implementer (Greenberg 2009; Fornell 2007) • core stakeholder values (de Groot, et. al. 2013) • 'situational awareness' (P.E.D. #1, #3, #4) • social trust in the project implementer (Siegrist, et al 2000) • trust asymmetry principle (Slovic 1993; Cvetkovich, et al 2002)

R(L)11: Social Trust vs. Benefit Loop	Increasing '**social trust in project implementer**' increases the '**probability benefit is received**'; increasing '**probability benefit is received**' increases '**perceived benefit from project**'; increasing '**perceived benefit from project**' increases '**stakeholder acceptance**'; increasing '**stakeholder acceptance**' increases '**degree of project implementer awareness of stakeholder values**'; increasing '**degree of project implementer awareness of stakeholder values**' increases '**perceived transparency of project implementer**'; increasing '**perceived transparency of project implementer**' increases '**social trust in project implementer**'	• Trust is easier to initiate, maintain and (if needed) recover as benefits are realized	• credibility of the project implementer (Greenberg 2009; Fornell 2007) • core stakeholder values (de Groot, et. al. 2013) • 'situational awareness' (P.E.D. #1, #3, #4) • trust asymmetry principle (Slovic 1993; Cvetkovich, et al 2002) • perceived vs. objective truth/differences in cognitive connections (e.g., Pachur, et al 2012; Finucane, et al 2000; Slovic & Peters 2006; Kahneman & Tversky 1979, 1982)
R(L)12(a&b): Stakeholder Acceptance vs. Radiation Attitudes Loop(s) (c)	a) Increasing '**stakeholder acceptance**' increases the '**radiation attitudes**'; increasing '**radiation attitudes**' increases '**perceived benefit from project**'; increasing '**perceived benefit from project**' increases '**stakeholder acceptance**' b) Increasing '**stakeholder acceptance**' increases the '**radiation attitudes**'; increasing '**radiation attitudes**' decreases '**perceived risk from project**'; decreasing '**perceived risk from project**' increases '**stakeholder acceptance**'	• Inextricable, dynamic link between individual beliefs and stakeholder acceptance that changes over time (e.g., new 'pro-nuclear' Green movement)	• socio-technical system framework (Sterman 2000; de Weck, et al 2011) • snowball nature of opinion change (Kasperson et al, 1980, 19) • perceived vs. objective truth/differences in cognitive connections (e.g., Pachur, et al 2012; Finucane, et al 2000; Slovic & Peters 2006; Kahneman & Tversky 1979, 1982) • differing perspectives of the nuclear acceptance (e.g., Santa Fe vs. Carlsbad on WIPP (Margolis 1997, 132) • rigorous model for individual radiation attitudes (Chandra 2014) • relationship between supporting nuclear projects as a concept and a specific nuclear facility nearby (Kasperson et al, 1980, 15) • operational vs. expected (or, speculative) benefits (Venables, et al 2009; Bezdek & Wendling 2006; Greenberg 2009; Flynn, et al 1993)

Table. F.3– State/National level CLD loop explanations.

State/Federal CLD	CLD Explanation	Conceptual Behavior Explained	Phenomena
R(S/N)1: Stakeholder Consensus vs. Political Controversy Loop	Increasing '**host state stakeholder consensus in support for specific nuclear project**' decreases the '**political controversy from supporting the specific nuclear project**'; decreasing '**political controversy supporting the specific nuclear project**' increases the '**host state constituent support for specific nuclear project**'; increasing '**host state constituent support for specific nuclear project**' increases '**host state stakeholder consensus in support for specific nuclear project**'	• Reinforcing influence of social 'controversy' attached to a specific nuclear project on constituent (e.g., local voter) support	• Congressional dynamics (WIPP vs. SONGS case studies) • 'no surprises' strategy stakeholder outreach (P.E.D. #1, #2, #3, #4) • core stakeholder values (de Groot, et. al. 2013) • 'situational awareness' (P.E.D. #1, #3, #4) • differing perspectives of the nuclear acceptance (e.g., Santa Fe vs. Carlsbad on WIPP (Margolis 1997, 132) • popular culture and social perceptions of 'nuclear things' (Weart 1998, 2012; Mahaffy 2014; Zemand & Amundson 2004) • socio-technical system framework (Sterman 2000; de Weck, et al 2011)
R(S/N)2: Stakeholder Consensus vs. Re-Election Loop	Increasing '**host state stakeholder consensus in support for specific nuclear project**' decreases '**political controversy from supporting the specific nuclear project**'; decreasing '**political controversy supporting the specific nuclear project**' increases '**host state constituent support for specific nuclear project**'; increasing '**host state constituent support for specific nuclear project**' increases '**probability of host state Cong Rep re-election from supporting the specific nuclear project**'; increasing '**probability of host state Cong Rep re-election from supporting the specific nuclear project**' increases '**politician support of specific nuclear project by host state Cong Reps**'; increasing '**politician support of specific nuclear project by host state Cong Reps**' increases '**host state stakeholder consensus in support for specific nuclear project**'	• Importance of voters to state government and state-specific representatives in federal government (e.g., those beholden to the cares of the voters) accepting nuclear projects	• Congressional dynamics (WIPP vs. SONGS case studies) • core stakeholder values (de Groot, et. al. 2013) • 'situational awareness' (P.E.D. #1, #3, #4) • differing perspectives of the nuclear acceptance (e.g., Santa Fe vs. Carlsbad on WIPP (Margolis 1997, 132) • relationship between supporting nuclear projects as a concept and a specific nuclear facility nearby (Kasperson et al, 1980, 15)

R(S)3: Political Benefit from Project Support Loop	Increasing '**host state Cong Rep political benefit of supporting specific nuclear project**' increases '**politician support of specific nuclear project by host state Cong Reps**'; increasing '**politician support of specific nuclear project by host state Cong Reps**' increases '**host state stakeholder consensus in support for specific nuclear project**'; increasing '**host state stakeholder consensus in support for specific nuclear project**' decreases '**political controversy from supporting specific nuclear project**'; decreasing '**political controversy from supporting the specific nuclear project**' increases '**host state Cong Rep political benefit of supporting specific nuclear project**'	• Extent to which a new nuclear project is associated with increasing political power, standing or influence	• operational vs. expected (or, speculative) benefits (Venables, et al 2009; Bezdek & Wendling 2006; Greenberg 2009; Flynn, et al 1993) • Congressional dynamics (WIPP vs. SONGS case studies) • core stakeholder values (de Groot, et. al. 2013) • 'situational awareness' (P.E.D. #1, #3, #4) • relationship between supporting nuclear projects as a concept and a specific nuclear facility nearby (Kasperson et al, 1980, 15)
R(S/N)4: Project Implementer Expectations & Approvals Loop	Increasing '**regulating entity confidence in project implementer**' decreases the '**time to consider regulatory approvals**'; decreasing '**time to consider regulatory approvals**' decreases '**additional regulatory approval expectations**'; decreasing '**additional regulatory approval expectations**' increases '**project implementer ability to meet regulating entity expectations**'; increasing '**project implementer ability to meet regulating entity expectations**' increases '**perceived project implementer regulatory approval application quality**'; increasing '**perceived project implementer regulatory approval application quality**' increases '**regulating entity confidence in project implementer**'	• Relationship where lacking confidence in project implementer can generate increasing number of tasks to be completed – possibly becoming prohibitive	• credibility of the project implementer (Greenberg 2009; Fornell 2007) • popular culture and social perceptions of 'nuclear things' (Weart 1998, 2012; Mahaffy 2014; Zemand & Amundson 2004) • 'no surprises' strategy stakeholder outreach (P.E.D. #1, #2, #3, #4) • core stakeholder values (de Groot, et. al. 2013) • 'situational awareness' (P.E.D. #1, #3, #4)

R(S/N)5: One-of-a-Kind Uncertainty vs. Mistakes Loop	Increasing '**one-of-a-kind nuclear project design uncertainty**' increases the '**one-of-a-kind nuclear project construction uncertainty**'; increasing '**one-of-a-kind nuclear project construction uncertainty**' increases '**mistakes, mishaps, re-work**'; increasing '**mistakes, mishaps, re-work**' increases '**one-of-a-kind nuclear project design uncertainty**'	• Extent to which expected growing pains of new technology implementation become unwieldy and problematic (e.g., increasing political pressure to meet next deliverable)	• 'no surprises' strategy stakeholder outreach (P.E.D. #1, #2, #3, #4) • nuanced, cognitive conception of risk (Margolis 1996, 1997) • socio-technical system framework (Sterman 2000; de Weck, et al 2011) • dynamics associated with 'one-of-a-kind' facility cost (WIPP vs. SONGS case studies)
R(S/N)6: Learning vs. Continued Operations Loop	Increasing '**lessons learned**' increases the '**improved project implementer capability with one-of-a-kind nuclear project**'; increasing '**improved project implementer capability with one-of-a-kind nuclear project**' decreases '**mistakes, mishaps, re-work**'; decreasing '**mistakes, mishaps, re-work**' increases '**probability specific nuclear project commences/continues operations**'; increasing '**probability specific nuclear project commences/continues operations**' increases '**lessons learned**'	• Importance of learning from and improving upon mistakes for a new nuclear project to continue operations	• 'no surprises' strategy stakeholder outreach (P.E.D. #1, #2, #3, #4) • nuanced, cognitive conception of risk (Margolis 1996, 1997) • socio-technical system framework (Sterman 2000; de Weck, et al 2011) • dynamics associated with 'one-of-a-kind' facility cost (WIPP vs. SONGS case studies) • credibility of the project implementer (Greenberg 2009; Fornell 2007) • snowball nature of opinion change (Kasperson et al, 1980, 19)
R(S/N)7: Willingness to Pay vs. Overrun Loop	Increasing '**specific nuclear project cost overrun**' increases the '**oversight entity reported specific nuclear facility cost**'; increasing '**oversight entity reported specific nuclear facility cost**' decreases '**national "willingness to pay" for specific nuclear project**'; decreasing '**national "willingness to pay" for specific nuclear project**' increases '**political controversy from supporting the specific nuclear project**'; increasing '**political controversy from supporting the specific nuclear project**' decreases '**probability of adequate Congressional funding**'; decreasing '**probability of adequate Congressional funding**' increases '**specific nuclear project cost overrun**'	• Utility of a new nuclear project continually declines as schedules slip and budgets get adjusted	• Congressional dynamics (WIPP vs. SONGS case studies) • popular culture and social perceptions of 'nuclear things' (Weart 1998, 2012; Mahaffy 2014; Zemand & Amundson 2004) • snowball nature of opinion change (Kasperson et al, 1980, 19) • 'situational awareness' (P.E.D. #1, #3, #4) • 'no surprises' strategy stakeholder outreach (P.E.D. #1, #2, #3, #4) • operational vs. expected (or, speculative) benefits (Venables, et al 2009; Bezdek & Wendling 2006; Greenberg 2009; Flynn, et al 1993)

R(S/N)8: National Willingness to Pay vs. Controversy Loop	Increasing '**national "willingness to pay" for specific nuclear project**'; decreases '**political controversy from supporting the specific nuclear project**'; decreasing '**political controversy from supporting the specific nuclear project**' decreases '**national expected specific nuclear project cost**'; decreasing '**national expected specific nuclear project cost**' increases '**national "willingness to pay" for specific nuclear project**'	• Utility of new nuclear project continually declines as associated political controversy persists	• Congressional dynamics (WIPP vs. SONGS case studies) • popular culture and social perceptions of 'nuclear things' (Weart 1998, 2012; Mahaffy 2014; Zemand & Amundson 2004) • snowball nature of opinion change (Kasperson et al, 1980, 19) • 'situational awareness' (P.E.D. #1, #3, #4) • 'no surprises' strategy stakeholder outreach (P.E.D. #1, #2, #3, #4) • operational vs. expected (or, speculative) benefits (Venables, et al 2009; Bezdek & Wendling 2006; Greenberg 2009; Flynn, et al 1993) • relationship between supporting nuclear projects as a concept and a specific nuclear facility nearby (Kasperson et al, 1980, 15)
R(S/N)9: State/Local Benefits vs. Political Controversy Loop	Increasing '**probability specific nuclear project commences/continues operations**' increases '**state/local economic benefits of specific nuclear project received**'; increasing '**state/local economic benefits of specific nuclear project received**' increases '**actual value of the specific nuclear project**'; increasing '**actual value of the specific nuclear project**' decreases '**political controversy from supporting the specific nuclear project**'; decreasing '**political controversy from supporting the specific nuclear project**' increases '**probability of adequate Congressional funding**'; increasing '**probability of adequate Congressional funding**' decreases '**specific nuclear project cost overrun**'; decreasing '**specific nuclear project cost overrun**' increases '**probability specific nuclear project commences/continues operations**'	• Benefits accrued by some can temper opposition/ controversy of many	• Congressional dynamics (WIPP vs. SONGS case studies) • operational vs. expected (or, speculative) benefits (Venables, et al 2009; Bezdek & Wendling 2006; Greenberg 2009; Flynn, et al 1993) • differing perspectives of the nuclear acceptance (e.g., Santa Fe vs. Carlsbad on WIPP (Margolis 1997, 132) • relationship between supporting nuclear projects as a concept and a specific nuclear facility nearby (Kasperson et al, 1980, 15) • socio-technical system framework (Sterman 2000; de Weck, et al 2011)

R(S/N)10: Cost Overrun vs. Non-Host State Support (with need) Loop	Increasing '**support from non-host state Cong Reps with specific need for specific nuclear project**' increases '**probability of adequate Congressional funding**'; increasing '**probability of adequate Congressional funding**' decreases '**specific nuclear project cost overrun**'; decreasing '**specific nuclear project cost overrun**' increases '**support from non-host state Cong Reps with specific need for specific nuclear project**'	• A state's need for the services of the new nuclear project tends toward higher acceptable cost overrun	• Congressional dynamics (WIPP vs. SONGS case studies) • operational vs. expected (or, speculative) benefits (Venables, et al 2009; Bezdek & Wendling 2006; Greenberg 2009; Flynn, et al 1993) • relationship between supporting nuclear projects as a concept and a specific nuclear facility nearby (Kasperson et al, 1980, 15) • socio-technical system framework (Sterman 2000; de Weck, et al 2011) • popular culture and social perceptions of 'nuclear things' (Weart 1998, 2012; Mahaffy 2014; Zemand & Amundson 2004)
R(S/N)11: Cost Overrun vs. Non-Host State Support (without need) Loop	Increasing '**support from non-host state Cong Reps without specific need for specific nuclear project**' increases '**probability of adequate Congressional funding**'; increasing '**probability of adequate Congressional funding**' decreases '**specific nuclear project cost overrun**'; decreasing '**specific nuclear project cost overrun**' increases '**support from non-host state Cong Reps without specific need for specific nuclear project**'	• A state's lack of need for the services of the new nuclear project tends toward lower acceptable cost overrun	• Congressional dynamics (WIPP vs. SONGS case studies) • operational vs. expected (or, speculative) benefits (Venables, et al 2009; Bezdek & Wendling 2006; Greenberg 2009; Flynn, et al 1993) • relationship between supporting nuclear projects as a concept and a specific nuclear facility nearby (Kasperson et al, 1980, 15) • socio-technical system framework (Sterman 2000; de Weck, et al 2011) • popular culture and social perceptions of 'nuclear things' (Weart 1998, 2012; Mahaffy 2014; Zemand & Amundson 2004)

R(S/N)12: Accumulated Benefit & Expansion Loop	Increasing '**probability specific nuclear project commences/continues operations**' increases '**tangible SNM benefit**'; increasing '**tangible SNM benefit**' increases '**national SNM perception*****'; increasing '**national SNM perception*****' increases '**probability of expanding specific nuclear project operational scope**'; increasing '**probability of expanding specific nuclear project operational scope**' increases '**actual value of the specific nuclear project**'; increasing '**actual value of the specific nuclear project**' decreases '**political controversy from supporting the specific nuclear project**'; decreasing '**political controversy from supporting the specific nuclear project**' increases '**probability of adequate Congressional funding**'; increasing '**probability of adequate Congressional funding**' decreases '**specific nuclear project cost overrun**'; decreasing '**specific nuclear project cost overrun**' increases '**probability specific nuclear project commences/continues operations**'	• Dynamic by which benefits accrued lead to desires for 'more of a good thing' & scope creep	• Congressional dynamics (WIPP vs. SONGS case studies) • operational vs. expected (or, speculative) benefits (Venables, et al 2009; Bezdek & Wendling 2006; Greenberg 2009; Flynn, et al 1993) • relationship between supporting nuclear projects as a concept and a specific nuclear facility nearby (Kasperson et al, 1980, 15) • socio-technical system framework (Sterman 2000; de Weck, et al 2011) • popular culture and social perceptions of 'nuclear things' (Weart 1998, 2012; Mahaffy 2014; Zemand & Amundson 2004) • dynamics associated with 'one-of-a-kind' facility cost (WIPP vs. SONGS case studies) • snowball nature of opinion change (Kasperson et al, 1980, 19)

B(S/N)1: Peer Pressure vs. Cost Overrun Loop	Increasing '**specific nuclear project cost overrun**' increases the '**oversight entity reported specific nuclear project cost**'; increasing '**oversight entity reported specific nuclear project cost**' decreases '**national "willingness to pay" for specific nuclear facility**'; decreasing '**national "willingness to pay" for specific nuclear facility**' increases '**essential stakeholder "peer pressure" for continued specific nuclear project operations/construction**'; increasing '**essential stakeholder "peer pressure" for continued specific nuclear project operations/construction**' increases '**pressure to control specific nuclear project costs**'; increasing '**pressure to control specific nuclear project costs**' decreases '**specific nuclear project cost overrun**'	• Extent to which state/federal stakeholders who need the new nuclear project act to influence the project implementer to do everything necessary to complete or continue the project	• Congressional dynamics (WIPP vs. SONGS case studies) • core stakeholder values (de Groot, et. al. 2013) • 'situational awareness' (P.E.D. #1, #3, #4) • relationship between supporting nuclear projects as a concept and a specific nuclear facility nearby (Kasperson et al, 1980, 15)

B(S/N)2: Accumulated Benefit vs. Operational Limits Loop	Increasing '**probability specific nuclear project commences/continues operations**' increases '**tangible SNM benefit**'; increasing '**tangible SNM benefit**' increases '**operations approaching limits of capability**'; increasing '**operations approaching limits of capability**' increases '**probability of need to (re)design specific nuclear project construction/expansion**'; increasing '**probability of need to (re)design specific nuclear project construction/expansion**' decreases '**probability of expanding specific nuclear project operational scope**'; decreasing '**probability of expanding specific nuclear project operational scope**' decreases '**actual value of the specific nuclear project**'; decreasing '**actual value of the specific nuclear project**' increases '**political controversy from supporting the specific nuclear project**'; increasing '**political controversy from supporting the specific nuclear project**' decreases '**probability of adequate Congressional funding**'; decreasing '**probability of adequate Congressional funding**' increases '**specific nuclear project cost overrun**'; increasing '**specific nuclear project cost overrun**' decreases '**probability specific nuclear project commences/continues operations**'	• Dynamic by which benefits accrued lead to reduced capacity to continue operations	• Congressional dynamics (WIPP vs. SONGS case studies) • operational vs. expected (or, speculative) benefits (Venables, et al 2009; Bezdek & Wendling 2006; Greenberg 2009; Flynn, et al 1993) • relationship between supporting nuclear projects as a concept and a specific nuclear facility nearby (Kasperson et al, 1980, 15) • socio-technical system framework (Sterman 2000; de Weck, et al 2011) • credibility of the project implementer (Greenberg 2009; Fornell 2007)